ASTM Bulletin Index

Author Index

(*R*) denotes 10 or more references.

Subject Index

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235

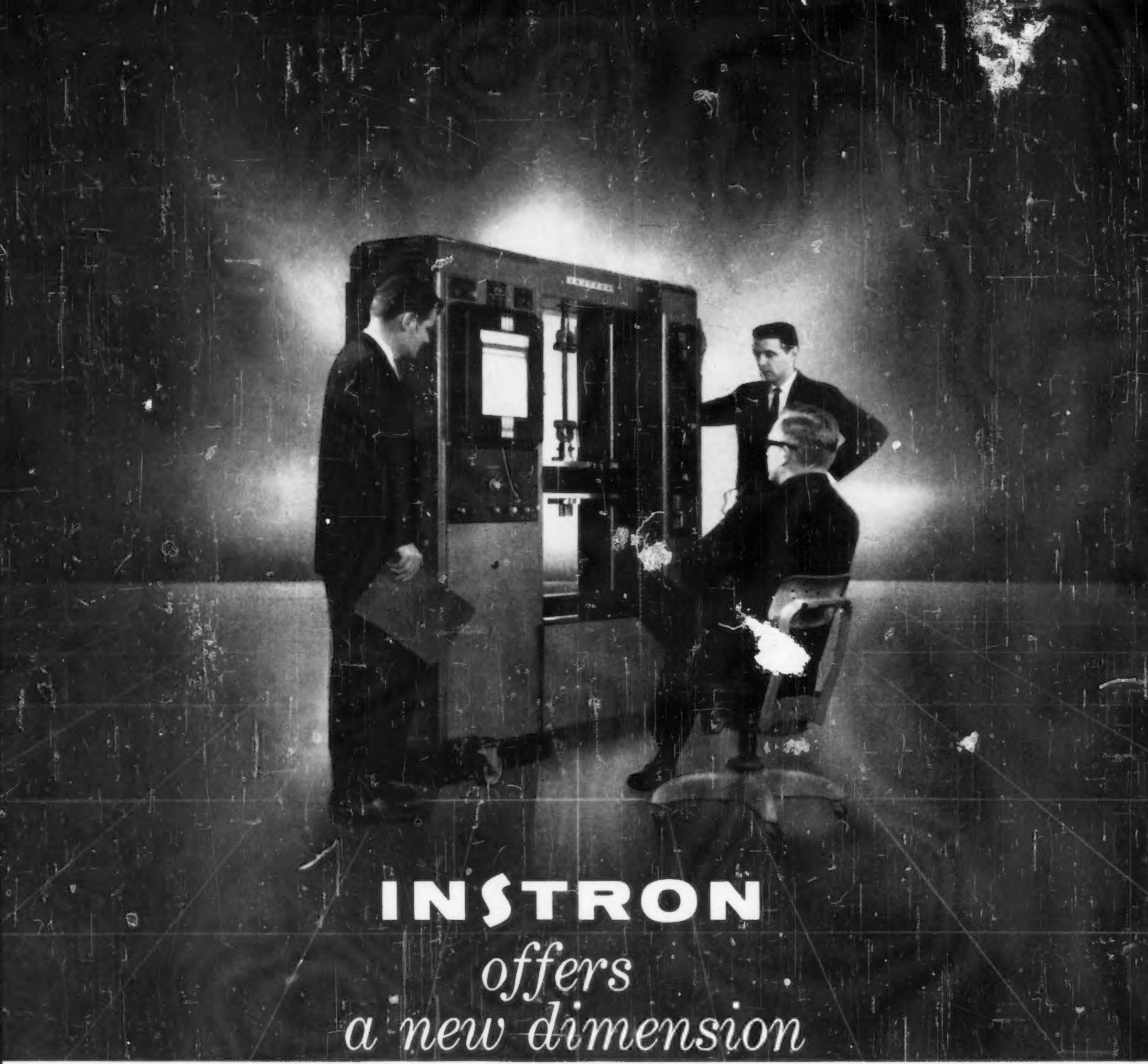
JANUARY, 1959
No. 235

ASTM Bulletin

ASTM IN 1958 . . .

The Challenge for Space-Age Materials

American Society for Testing Materials



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ASTM BULLETIN

January 1959 — **Number 235**

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TECHNICAL PAPERS

RESEARCH AND STANDARDS IN ACTION

DEPARTMENTS

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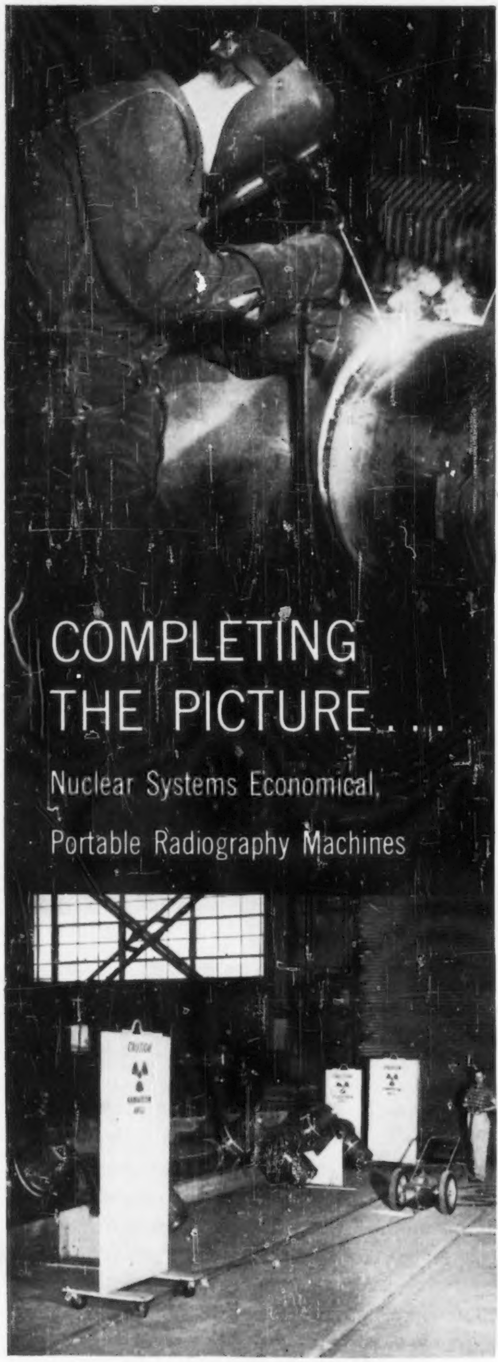

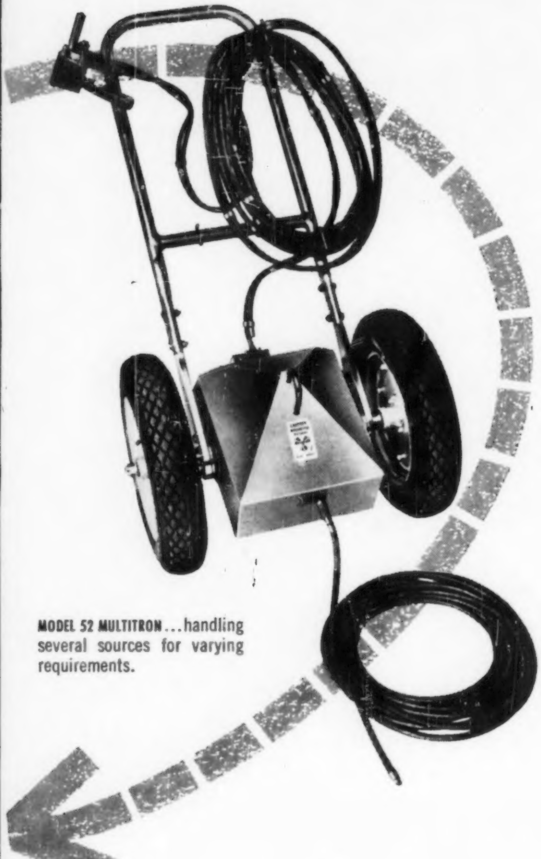

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ASTM BULLETIN

Research and Standards for Materials

Number 235 | January 1959

ASTM IN 1958 . . .

. . . Faces Challenge for Space-Age Materials

. Radiation Effects

. High Temperatures

. Nuclear Reactor Materials

. Reliability

. Fundamentals of Materials

. Information Storage and Retrieval

ALTHOUGH THE first sputnik was launched late in 1957, the year 1958 may properly be called the first year of the age of space. The satellites, first projected as a part of the International Geophysical Year, have captured the imagination of nearly everyone, lay and scientific-technical people alike. With the end of the IGY, interest in these projects show no signs of abatement. The possibilities of space exploration spark a little of the Marco Polo or Christopher Columbus in all of us.

With the space age hard on the heels of the nuclear age, extreme demands are being made upon our technical resources. Materials are needed that will perform under extreme environments—very high temperatures, high radiation fields, shock and vibration, and combinations of these.

There is exciting new knowledge—in molecular and solid state physics, in chemistry, in metallurgy—that has been of great assistance in meeting some of the present space-age challenge. But more fundamental knowledge is needed, as are more systematic means for storing and retrieving the accumulating mass of data.

In 1958 the Society took some important steps toward meeting the challenge and through its Long-Range Planning Committee laid the ground-

The Great Nebula in Andromeda

Space-Age Marco Polos will need super materials for extreme environments.

work for many more constructive changes to keep pace with these new technological demands.

Here are some of the ways ASTM is meeting the space-age challenge.

• Radiation Effects. How radiation dose is measured in various laboratories, information on radiation facilities and techniques, and reports of radiation studies may be found in "Symposium on Radiation Effects" recently published by the Society (STP 233). This was the third joint symposium with the Atomic Industrial Forum and represents a part of the Society's continuing effort to disseminate technical information on nuclear matters.

Committee E-10 on Radioisotopes and Radiation Effects is assisting the Society's technical committees as well as industry generally in the use of radioisotopes in materials testing, and in coordinating the Society's efforts in radiation effects studies and standards.

"Recommended Practice for the Exposure of Polymeric Materials to High Energy Radiation" is the title of a draft now being balloted in the subcommittee on radiation effects of the committees on plastics and electrical insulation. When approved, this standard will facilitate the collection and correlation of data on radiation effects on plastics and related polymeric materials.

• High Temperatures. Ablation resistance of plastics is a measure of the degree to which a plastic will remain intact and provide some thermal insulation when exposed for short times —usually seconds or minutes—at extremely high temperatures such as might be encountered by aerodynamic heating of missile surfaces or by heat from rocket exhaust gases. "Ablation Resistance" is the subject of a new working section of Committee D-20 on Plastics. In the same committee, another group is working on high-temperature properties generally of reinforced plastics.

Evidence of increasing needs for high-temperature metals—cobalt, columbium, chromium, molybdenum, nickel and tungsten—was presented by Clyde Williams in his Gillett Memorial Lecture at the 1958 Annual Meeting. Studies toward specifications for these metals are going forward in Committee B-2 on Non-Ferrous Metals.

The Joint Committee with ASME continues to develop data on high-temperature properties of metals. Recently released is a report on "Properties of Cast Iron at Elevated Temperatures," STP 248.

• Nuclear Reactor Materials. Nuclear reactor materials—that is, materials having special properties or requirements because of applications associated with nuclear reactors—are being considered on such a broad front in ASTM committees that the subject will be treated in a special article in a forthcoming issue of the BULLETIN. Specifications and tests being written or existing standards being modified for nuclear applications cover stainless steels (plate, sheet, and strip; tubing and piping; bolting; and forgings and castings), non-ferrous metals and alloys (beryllium, columbium, lithium, uranium, zirconium, hafnium, and others), as well as light metals and alloys. Among the nonmetallics, work is in progress on concrete for shielding, ceramics, petroleum products, electrical insulation, and plastics.

• Reliability. Problems of reliability are generally considered in terms of function of completed systems or equipment and rarely in terms of materials. But the properties of materials and the precision of their measurement are most important reliability factors. The old story of the loss of a horseshoe nail has a modern version in the function of electron tube parts as this affects an electronic system. How these parts are cleaned and assembled and how the degree of cleanliness (or contamination) is measured was considered in a two-day symposium held in October, 1958, and now being published as STP 246. Cleanliness of tube parts has been shown to have a high correlation with tube performance and reliability.

Estimates of the life of small electrical contacts also important for reliability may be made based on results of a new test for resistance characteristics of microcontacts (B 326 – 58 T) approved by the Society at the 1958 Annual Meeting.

• Fundamentals of Materials. "Materials Research Frontiers," a symposium at the 1958 Annual Meeting, included papers by experts on the fundamentals of all major categories of materials—metals, ceramics, polymers, petroleum products, and nuclear materials. Plenty of evidence was presented to indicate that the Society can advance knowledge of materials by studying them at molecular and atomic levels as well as by empirical or engineering tests.

Recognizing the need for some kind of Society forum for fundamental problems, the Directors and the Long-Range Planning Committee are considering organizing a committee or a division of the Society to provide such a forum. The Society's standardization program also will gain much from greater participation by materials scientists as well as engineers.

Two new administrative committees have been organized—on Education with Prof. Glenn Murphy of Iowa State University as chairman, and on Fellowships and Grants in Aid with Dean A. T. Mavis of the University of Maryland, as chairman. These committees will offer guidance to the Society in the field of education.

• Information Storage and Retrieval. Data developed by several ASTM committees regularly are filed on punched cards for machine sorting, correlation, and retrieval. While this is not new, it probably indicates a future trend toward greater application in the Society. Currently available on IBM cards are infrared and ultraviolet absorption data on a wide variety of chemical compounds and products. X-ray diffraction data are similarly available.

Physical properties of metals at elevated temperatures are now being entered on punched cards as a project of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. This could portend the eventual accessibility on punched cards of all significant materials data in ASTM publications, though it is not likely to happen soon.

The Society is represented on the Advisory Committee to the Office of Critical Tables of the National Academy of Sciences–National Research Council by M. V. Otis of Tennessee Eastman Co. Mr. Otis is chairman of the Data Section of Committee E-13 on Absorption Spectroscopy.

New Projects

In keeping with expanding industry needs, the Society continues to enlarge its technical committee operations. Not only were many new projects added to the work load of existing committees but several new committees were established.

Cleaning Solvents. Committee D-26 on Halogenated Organic Solvents was officially organized at the 1958 Annual Meeting in Boston. Its scope covers specifications and tests for halogenated solvents—carbon tetrachloride, perchloroethylene, etc.—as well as health and safety aspects.

Industrial Chemicals. A new Committee E-15 on Analysis and Testing

of Industrial Chemicals will be organized early in 1959. The scope has been approved by the Board of Directors (ASTM BULLETIN, September, 1958, p. 20).

Ferrites. While ferrites are currently under a group of Committee C-21 on Ceramic Whitewares, there is also interest in other ASTM committees. This is a group to watch—it may be established later as a separate committee.

Insulating Liquids and Gases. This will be the subject of a new committee to be organized in 1959 if a recommendation of Committee D-9 on Electrical Insulating Materials is approved in January by the Directors. Nucleus of the new group is Committee D-9, Subcommittee IV on Insulating Liquids, F. M. Clark, chairman.

Gaskets. A study committee under the chairmanship of M. H. Kapps has distributed a questionnaire to survey interest in expanding the Society's work on gaskets. The present work on gaskets is confined to automotive uses and is under Committee D-11 on Rubber jointly with the Society of Automotive Engineers.

Cermets. A study committee on cermets, J. R. Tinklepaugh, chairman, has recommended to the Society that a coordinating committee be established representing the interests in cermets in existing technical committees.

Research and Standards Highlights

METALS

FERROUS METALS

Just as in 1957, the heavy construction program resulted during 1958 in the development of new specifications covering, respectively, stress-relieved wire for prestressed concrete (A 421), and high-strength billet-steel bars for concrete reinforcement (A 431). In 1957 the new basic oxygen process of steelmaking was approved for steel pipe furnished to specifications A 120. In 1958 the new process was approved for pipe furnished to specification A 53, as well as for many specifications covering structural steel, concrete reinforcing steel, bar steel, and sheet and strip steel.

During the Korean War and its accompanying nickel shortage, substitutes for the regular chromium-nickel grades of stainless steel were developed by substituting manganese for some of the nickel, the results being known as types 201 and 202 stainless. In 1957 specification A 421 for plate, sheet, and strip of these steels was issued. In 1958 specification A 429 was published, covering bars of types 201 and 202 stainless.

Tubular Products

A number of significant new specifications for steel tubular products have been issued. In some applications of still tubes in refineries, it has become necessary to join lengths by butt welding. To standardize this procedure, specification A 422 was developed. In some pressure-containing parts such as economizers, corrosion resistance is important. Low-alloy steel tubes have been found suitable for such purposes, and specification A 423 covers this product in seamless and electric welded form. Centrifugally cast alloy-steel pipe is being used for oil refinery and other high-temperature service. Suitable centrifugal pipe for bending, flanging, fusion welding, and similar forming operations can be purchased in accordance with specifications A 426. The power industry uses quantities of very heavy wall pipe made from turned and bored forgings for central station service. In 1955 specifications A 369 were developed for this product when made from ferritic alloy steel. With the trend toward higher temperatures and pressures, austenitic alloy steel became necessary for the new power plants and specifications A 430 cover this product.

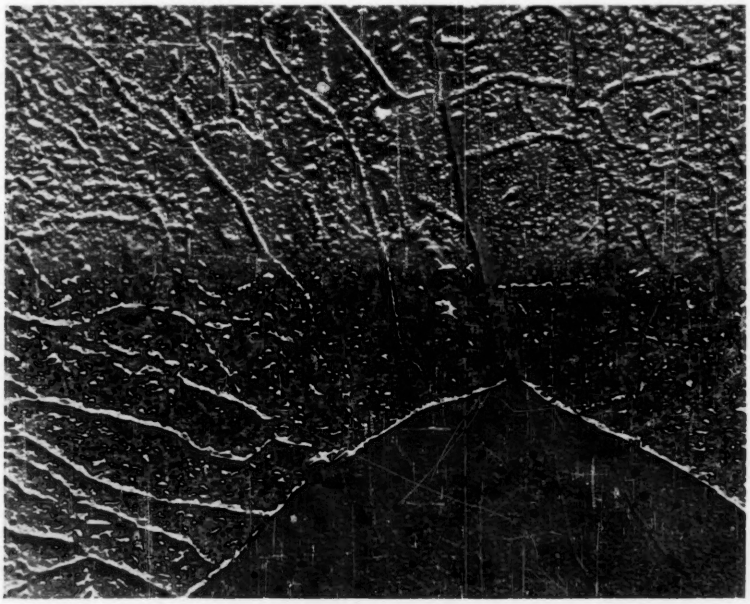
Coated Articles

A product of increasing importance in the metal industry is aluminum-coated iron or steel. The first step in writing industry-wide specifications was accomplished in 1958 with the publication of methods for determining the weight of coating on aluminum-coated iron or steel sheets and wire (A 478).

NON-FERROUS METALS

Standardization activities in non-ferrous metals were very heavy during 1958. Although the titanium bubble in the aircraft industry seems to have burst, other fields such as the chemical industry and the nuclear industry have become quite interested in this metal. As a result, specification B 265 was revised to reflect industry practice in supplying titanium and titanium alloys in the form of sheet, strip, and plate. Likewise, specification B 299 was revised to reflect the production of better grades of titanium sponge. In addition, new specifications were written for titanium tubing (B 338) and titanium pipe (B 337). In the final stages of approval is the specification for titanium and titanium alloy bars and billets.

The ten existing ASTM specifications for nickel and nickel alloy products (nickel, monel, and inconel flat products, bars, and pipe and tubing) were heavily revised. Also new specifications were



Subgrains in Pure Iron

Specimen was standardized, strained 9 per cent in tension and annealed at 700 C for 1 hr. Magnification 16,500 X, reduced for publication. First Prize, Student Entries, Photomicrographs, Black and White, Eleventh ASTM Photographic Exhibit. Charles Hays, University of Kentucky, Lexington, Ky.

written for nickel-molybdenum (Hastelloy B) and nickel-molybdenum-chromium (Hastelloy C) flat products, rod, and castings.

Non-ferrous products such as lead and tin also were in the news. For some years a need has been seen for industry-wide specifications for pig lead mad from scrap by smelting and refinin. There was not much question over the requirements for the product, but the question of terminology entailed much discussion. In 1958 agreement was reached, and the specifications for refined secondary lead (B 325) were issued.

In about 1950 voices became quite strong for specifications or a classification of tin that would give a more orderly or precise designation than trade brands. In the early stages of seeking information on tin, it was soon evident that there was much misinformation and a lack of understanding. As a result, a symposium on tin was sponsored at the 1952 Annual Meeting to develop some factual information. In 1958 agreement was finally reached on a classification of pig tin. As this article is being written the proposed document is being considered for approval by the Administrative Committee on Standards.

EFFECT OF TEMPERATURE

During 1958, the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals completed a number of research projects.

An investigation of the elevated temperature properties of cast iron, begun in 1953, was completed in 1958 at the Southern Research Inst., Birmingham, Ala. The purpose of this investigation was to determine whether low-alloy cast irons can safely be used for load-carrying applications at temperatures above the presently specified maximum of 650 F. A complete report covering this project will be published early in 1959 as a *Special Technical Publication*.

STP 228 on the "Elevated Temperature Properties of Chromium Steels (12 to 27 per cent)," prepared by the joint committee, was published in 1958. This report, which presents a graphic summary of the elevated temperature strength properties for chromium steels, includes data on tensile strength, yield strength, elongation, rupture, and creep properties for 23 alloys. A great deal of the data in this publication was obtained from cooperating laboratories. The material was prepared by Battelle Memorial Institute.

A project on elevated temperature properties of weld-deposited metal and weldments was completed in 1958, and the results published as STP 226. This is probably the first publication that attempts to draw together in one place all the available elevated-temperature test data on steels and similar alloys, as represented by current good welding practices. This work was done at the University of Michigan.

Literature surveys covering three subjects have also been completed. The work was done under contract as follows:

1. Creep damage, with the University of Michigan.
2. Notch rupture behavior, with Syracuse University.
3. Effect of cyclic loading, with NACA through Syracuse University.

Plans for publication of these surveys are being formulated.

Currently the joint committee has a number of research projects under way which may be completed in 1959 or 1960. Some of the work is being done in cooperative laboratories and requires no committee funds. Other phases are under contract and are being financed by the committee.

Standards Developed

The committee revised the recommended practice for short-time elevated-temperature tension tests of materials (E 21 – 58 T) in order to make these procedures adequate for present needs in the field of testing at elevated temperatures. This represents the best possible compromise on controversial points in conducting the tests.

The new recommended practice for conducting creep and time-for-rupture tension tests of materials (E 139 – 58 T) replaces the former recommended practices E 22 and E 85.

The test methods panel is developing a program to provide standard specimens for calibrating creep-rupture test equipment. Also a task group will advise the panel on needs for elevated temperature testing procedures for metallic materials as used in the aviation industries.

METALLOGRAPHY

Since 1946 methods E 3 describing the preparation of metallographic specimens have remained unchanged, although developments in the field have been many and varied. Recently, steps were taken to bring the procedures up to date. During 1958 a new section on electrolytic polishing was approved and added. As more data are accumulated in other areas, additional revisions of the methods will result.

In 1955, methods E 112 for estimating the grain size of metals was published. The basic procedures in these methods were offered for universal metallurgical application and were intended eventually to replace the other existing grain size methods which evolved from several different branches of metallurgical products. Information was obtained during 1956 and 1957 from the ASTM committees writing product specifications, which led to a further revision of E 112 in 1958 to make it more universally acceptable.

NONDESTRUCTIVE TESTING

Activity in the field of nondestructive testing is expanding at a rapid pace. This, of course, is only natural as a result of the need for procedures to test very expensive metal products, such as nuclear reactors and similar equipment, and to test them exhaustively to avoid costly service failures. In 1958 a detailed procedure for the ultrasonic inspection of turbine and generator rotor forgings (A 418) was issued. In ultrasonic testing, standard reference blocks are a necessity. The recommended practice for fabricating and checking aluminum alloy ultrasonic standard reference blocks (E 127) is intended to fill this need.

For three years an ASTM method for dry powder magnetic particle inspection (E 109) has been used extensively and is incorporated by reference in many steel product specifications. In 1958 a companion document covering the inspection of steel parts using wet magnetic particles (E 138) was published.

Another nondestructive method of inspection useful in the nuclear energy program employs eddy currents. In 1958 the nondestructive test committee organized a group to promulgate inspection methods using eddy currents and related techniques.

CORROSION

In June, 1958, the Task Group on Magnetic Gages brought to Committee A-5 on Corrosion of Iron and Steel a preliminary report on the interlaboratory study of specially prepared panels using four commercial magnetic gages. When the data have been statistically

analyzed, a specification will be prepared for this type of instrument.

A specification is in preparation for flat armor tape in which the use of copper-base steel is optional. It will include the number of welds per coil, a new class 3 coating of 2.00 oz per sq ft, tolerances, and camber.

Work is beginning on a specification for galvanized sheets of structural quality.

Interlaboratory tests are being continued to determine the reproducibility of the method of total immersion corrosion test of non-ferrous metals (B 185 – 43 T). Study so far indicates considerable inconsistency of results.

ELECTRODEPOSITED COATINGS

A draft has been completed for a specification for heavy industrial nickel and chromium coatings which will supersede the electrodeposited coatings of nickel and chromium on steel (A 166 – 58 T).

A project of considerable dimensions is under way to collect engineering data to standardize magnetic methods of determining thickness of electrodeposited coatings. At the completion of this study, recommendations will be made concerning the revision of the methods of test for local thickness of electrodeposited coatings (A 219 – 58).

In order to obtain better performance of decorative coatings or to reclaim plated parts, a new recommended practice for preparation of nickel for electroplating with nickel has been developed. The recommended practice will be presented for subcommittee action at the 1959 Annual Meeting.

CONSTRUCTION MATERIALS

CEMENT

An important development in the field of cement standards during 1958 was the establishment of a plan to coordinate Federal and ASTM standards, particularly test methods. Representatives from both the Federal Government and Committee C-1 on Cement will meet together informally when the Federal standards are under discussion. Steps toward unification of standards are being taken by the working subcommittees in suggesting revisions to several ASTM standards which will lead toward requirements and procedures similar to those in Federal standards. Similarly, government people are noting changes that are needed in Federal standards.

One new tentative method accepted by Committee C-1 in 1958 is a procedure for fineness of hydraulic cement by the No. 325 sieve, a method already included in Federal specifications. The use of low-alkali cement has been more completely defined, when reactive aggregates are present, in revisions to the specification for portland cement (C 150) and the specification for air-entraining portland cement (C 175).

MASONRY MORTAR

Methods of testing for efflorescence continues to be an active project of Committee C-12 on Mortars for Unit Masonry. A revised procedure is being recommended for publication as information in the ASTM BULLETIN. Realistic grading units for aggregates are being considered for a revision of the specification for aggregate for masonry mortar (C 144). The present specification for mortar for reinforced brick masonry (C 161 T) has been considered unsatisfactory for some time in view of the latest developments in masonry construction, and an entirely new specification is in preparation.

CHEMICAL-RESISTANT MORTARS

A procedure for determining the chemical resistance of mortars was agreed upon in 1958 by Committee C-3 on Chemical-Resistant Mortars. The test uses weight change and appearance of the exposed specimens and test solutions as guides for selection of mortars for particular applications.

Other recently accepted test methods for measuring properties cover working and initial setting times and the absorption and apparent porosity of chemical-resistant mortars. Flexural strength of silicate mortars and thermal expansion and shrinkage of all types of chemical-resistant mortars are receiving attention in the committee.

CONCRETE AND CONCRETE AGGREGATES

Nuclear energy installations have made good use of concrete for effective radiation shielding. Committee C-9 on Concrete will study the special requirements for this use, with a view toward the development of standards.

Vibrated concrete in construction has raised the question of the suitability of rodded and tamped concrete for test specimens. The need for a standard vibrating procedure for making test specimens is under consideration.

A method of test for abrasion-resistance characteristics of concrete, accepted at the 1958 Annual Meeting, involves the impingement of air-driven silica sand or steel grit.

A proposed tentative method of test for determining the effectiveness of mineral admixtures in preventing excessive expansion caused by alkali-aggregate reaction will provide a much needed tool for evaluating concrete mixtures involving these materials.

A few other important projects cover revisions in the Los Angeles abrasion test method (C 131); a procedure for determining the cement content of fresh concrete with the objective of measuring the efficiency of concrete mixers; and a procedure for evaluating the performance of concrete aggregates by freezing and thawing in concrete.

GYPSUM

The activity of Committee C-11 on Gypsum during 1958 included further refinement of methods of testing gypsum as well as the development of specifications to cover new gypsum products. Approved were a specification for gypsum backing board and a change in the specification for annular ringed nails for gypsum wallboard to cover the length of nails for application of gypsum. New projects under development include a specification for joint tape and cement and a friability test for perlite aggregate.

CONCRETE PIPE

Pipe for drainage purposes has received primary consideration by Committee C-13 on Concrete Pipe. A new specification for concrete drain tile (C 412 T) was accepted by the Society, following the transfer of jurisdiction to the committee, resulting in a separation from the older specification for drain tile (C 4). A proposed specification for perforated pipe was approved for pipe intended to be used for underdrainage with standard strength and extra-strength classifications.

Rubber-type gasket joints used in the installation of concrete pipe are covered in a proposed specification on gasket joints for circular concrete sewer and culvert pipe. A number of modifications were approved in the specification for non-reinforced concrete pipe for irrigation and drainage (C 118) which will affect the physical test requirements in respect to internal hydrostatic pressure and the three-edge bearing load values.

CLAY PIPE

New developments in joints for clay pipe are reflected in the acceptance of a specification for factory-made joints. The specification sets forth the individual qualities and minimum characteristics of performance for resilient materials used for factory-fabricated joints on vitrified clay pipe.

Additional coverage of products in the clay pipe field is anticipated soon with a proposed specification for clay liner plate now being prepared in Committee C-4 on Clay Pipe.

ASTM IN 1958 . . .

LIME

Sand-lime products, as typified by the specification for sand-lime building brick (C 73), are being used in increasing quantity in the building industry. Lime for sand-lime products has now been standardized with a specification approved by Committee C-7 on Lime and accepted by the Society at the 1958 Annual Meeting. This specification (C 415) covers both quicklime and hydrated lime.

Improvements in the quicklime production process have led to proposed revisions of the specification requirements, to permit the use of the slaked lime putty at a much shorter period than presently prescribed.

MANUFACTURED MASONRY UNITS

The determination of drying shrinkage of masonry units has been of concern to Committee C-15 on Manufactured Masonry Units. The Committee has approved a proposed tentative method for this purpose. A proposed method of test for determining the moisture condition of hardened concrete by the relative humidity method was also approved.

Exploratory tests of three silicone materials was completed as the first phase of the work to prepare a method of test to determine the effectiveness of coatings of waterproofing materials for unit masonry walls. A method of test is now under development, together with a test to measure the transpiration of water vapor through films of transparent water-retardant materials.

A number of revisions of the existing specifications for clay brick were approved by the Society as noted in the 1958 Annual Report. The preparation of a proposed specification for chemical-resistant ceramic tower packings progressed during the year, although the specifying of strength characteristics of complex shapes presents a problem.

NATURAL BUILDING STONES

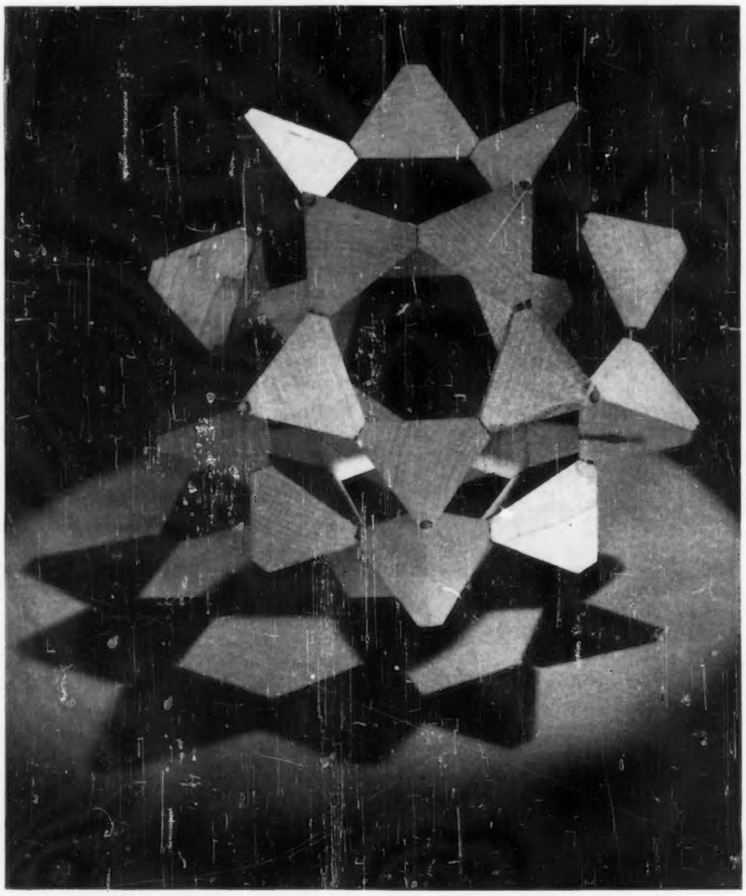
A new specification for building granite, accepted at the 1958 Annual Meeting, provides the second of a group of specifications covering natural building stones. A specification for roofing slate (C 406 T) was accepted by the Society in 1957. Progress was made in the development of proposed specifications to cover marble, sandstone, and limestone. The ASTM specifications are the only published standards which provide requirements based on physical properties the values for which can be determined by standard methods of test, thus getting away from the old procedure of selecting natural building stone by name and source only. Additional coverage is being given to definitions of terms relating to natural building stones.

GLASS AND GLASS PRODUCTS

A sieve analysis of raw materials used in the manufacture of glass received attention in Committee C-14 on Glass and Glass Products during 1958. A precise method of analysis through the use of standard matched sieves is being considered. Flame photometric methods for chemical analysis, as well as colorimetric methods, are being studied for a revision of the standard. An alternate method of polariscope examination of glass containers was prepared as a proposed revision of the method of polariscopic examination of glass containers (C 148). This new method will eliminate the need for standard disks, the supply of which has been depleted and the cost become prohibitive for further reproduction.

ASBESTOS-CEMENT PRODUCTS

A long-awaited specification for asbestos-cement sewer pipe was completed by Committee C-17 on Asbestos-Cement Products. The existing specification for asbestos-cement pressure pipe (C 296) was revised to bring it in line with the requirements of the new specification for sewer pipe. A revision in the specification for corrugated asbestos-cement sheets (C 221) providing requirements for lightweight corrugated material was approved by the committee.



The Vitron

The vitron, a submicroscopic arrangement of silicon-oxygen tetrahedra with fivefold axes of symmetry, is a new concept developed at the National Bureau of Standards for studying the structure of glass. Honorable Mention, Special Award; Eleventh ASTM Photographic Exhibit. William L. Smallwood, National Bureau of Standards, Washington, D. C.

THERMAL INSULATION

Several new test methods for thermal insulation accepted by the Society in 1958 cover a variety of purposes. One measures handleability using a laboratory tumbling mechanism to provide a combination of abrasion and impact stresses. Two other methods cover the making and curing of test specimens of all types of mastic thermal insulation coatings, and an additional thermal conductivity procedure for use at low temperatures.

Specifications for newer types of thermal insulation approved by the committee cover amosite asbestos insulation for pipes and reflective sheet insulation. Mechanical stability and emissivity are two properties which will be covered by standards.

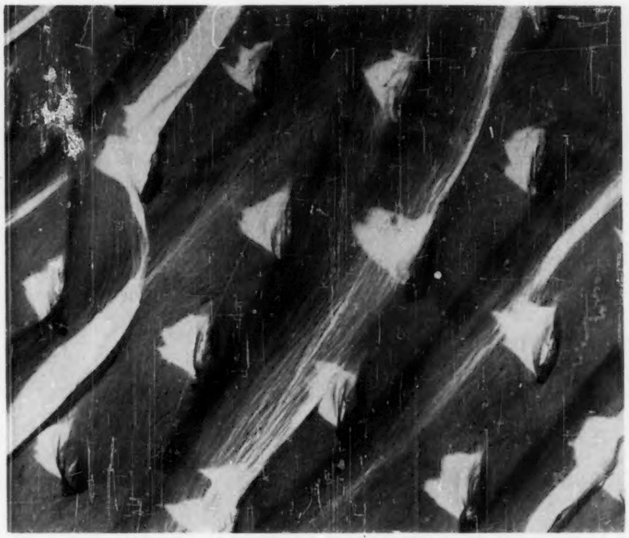
Entrance into the field of dimensional standards has been made by the committee with a recommended practice for prefabrication or field fabrication of thermal insulating fitting covers. This standard will have as reference material an extensive set of tables providing dimensional standards. The widely recognized thermal conductivity test method using the guarded hot plate (C 177) is receiving extensive study for further refinement.

STRUCTURAL SANDWICH CONSTRUCTIONS

Committee C-19 on Structural Sandwich Constructions has approved methods relating to the measurement of creep characteristics of sandwich constructions loaded in flexure at any desired temperature. Two methods are being developed for determining the resistance to peel of the bond between metal facings and core. One of these methods involves the use of the 4-in. diam hand or drum peel tester.

ACOUSTICAL MATERIALS

A highly sound-reflective room in which special care has been taken to make the sound field as diffuse as possible in order to secure measurements under conditions close to an actual installation is known as a reverberation room or chamber. A method of test was accepted by the Society in 1958 prepared by Committee C-20 on Acoustical Materials which describes this special room and outlines the measuring technique. Smaller-scale test methods for measuring sound absorption have also been under consideration; one, called the horn coupler method, uses specimens larger in area than those used in the existing ASTM impedance tube method (C 384). Both are laboratory scale tests.



Spiral Thickenings and Pits in a Basswood Vessel Segment

Inner layer of the secondary wall in a vessel segment of basswood, Tilia americana. Magnification 16,800 X, reduced for publication. First Prize, Student Entries—Electron Microscope; Eleventh ASTM Photographic Exhibit. Wilfred A. Cote, Jr., State University of New York, Syracuse, N. Y.

The importance of fire-resistance properties of acoustical materials has led to consideration of several small-scale test methods for evaluating flame spread or fire hazard characteristics. Included in this category are the tunnel test (E 84 T), the radiant panel test, and the modified panel test included in the Federal Specification SS-A-118a.

Mechanical suspension systems are receiving attention with the objective of developing test procedures for evaluating such properties as sag, load-carrying capacity, and corrosion resistance. The development of a test method for repaintability of acoustical materials is under consideration, this being an important factor in their sound-absorption efficiency.

ROAD AND PAVING MATERIALS

Test methods to determine the physical characteristics of bituminous mixtures received prominent attention in Committee D-4 on Road and Paving Materials. The resistance to plastic flow by means of the Marshall apparatus and the resistance to deformation and cohesion by means of the Hveem apparatus are covered in new tentative methods accepted at the 1958 Annual Meeting. A third new tentative method covering the preparation of bituminous mixtures by means of the California Kneading Compactor was also accepted.

Also accepted, were new tentatives relating to the testing of soils, including the sand-cone method for density of soil in place; moisture-density relationship determination by use of the 10-lb rammer and 18-in. drop; and a method for establishing the moisture-penetration resistance relations of fine-grained soils.

In view of the broad coverage of Committee D-4, it is possible to highlight only a few of the developments during 1958 with no mention of the many revisions of standards completed. A new method was approved by the committee for determining specific viscosity of tar products by means of the Engler apparatus. A procedure for determining the coating and stripping properties of bitumen-aggregate mixtures, now subject to letter ballot, provides a much needed method to help in solving the problem of stripping of aggregates in a bituminous mixture.

WOOD

The greatly expanded use of wood-base fiber and particle panel materials has directed activity in Committee D-7 on Wood toward the development of standards in this field. As an initial effort, a comprehensive list of definitions of terms relating to these materials was accepted at the 1958 Annual Meeting.

In contrast to this latest field of wood-type materials, the specification for wood paving blocks for exposed pavements (D 52), first published in 1918, was completely rewritten in 1958 to cover use in connection with exposed platforms, driveways, and interior floors subject to wet and dry conditions.

Additional wood preservatives included in specifications and test methods

approved by the committee are acid copper chromate, chromated copper arsenate, and chromated zinc arsenate. A new method for accelerated field tests of preservatives, which will provide a means of forecasting durability, has progressed to the draft stage.

BITUMINOUS ROOFING AND WATERPROOFING MATERIALS

The development of specifications for bituminized fiber pipe, representing an expansion of activities of Committee D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses, got under way in 1958. A newly formed subcommittee has been given assignments to cover physical, chemical, and dimensional requirements. A further expansion of scope will include the field of industrial pitches.

A group of test methods for surfacing materials for built-up roofing has been drafted for final consideration. A specification for woven glass fabrics has been completed, and a specification for felted glass fabric is still in process.

Cold-applied roofing materials of different kinds are receiving attention for possible specification formulation.

Two accelerated weathering test methods have been submitted to letter ballot, one for preparation of outdoor weathering test panels and the other for determining failure end point.

FIRE TESTS

The difficulty in defining noncombustibility of building materials is alleviated to a certain extent by a method of test for this purpose presented to the Society by Committee E-5 on Fire Tests of Materials and Construction. Using this method, a material is classed as noncombustible if it meets the requirements of the procedure outlined.

Flame spread ratings of interior finishes is a much needed requirement. Much attention has been given to a review of the existing ASTM Method E 84 T or so-called "large tunnel" test and to other, small scale tests whose use may or may not be confined to evaluation purposes.

The need for fire tests of windows has been under consideration. Further refinement in the large scale standard method of fire tests (E 119) was accomplished during 1958.

TESTING OF BUILDING CONSTRUCTIONS

Tests for structural properties of masonry unit construction are being developed by Committee E-6 on Methods of Testing Building Constructions. A distinctly different project is the preparation of test methods to evaluate vapor barriers used beneath concrete slabs on the ground, using data collected by the Forest Products Laboratory. The testing of window assemblies received preliminary study with information to be assembled as a result of a symposium on this subject to be held during the 1959 Committee Week.

SOILS

Sampling and testing methods for soils accepted by the Society in 1958 add materially to standardization in the difficult field of soils testing. Committee D-18 on Soils for Engineering Purposes presented three test methods, jointly under the jurisdiction of Committee D-4, pertaining to moisture-penetration, moisture-density relations, and density in place, all described briefly above under "Road and Paving Materials." Two sampling methods, one being the thin-walled tube method and the other the split-barrel method, are now published as tentative.

The formulation of a method of wet preparation of soil samples for grain-size analysis is underway, as are also procedures for measuring the permeability of coarser textured soils and the capillarity of sands and fine-textured soils. As measures of structural properties, proposed methods for consolidation, direct shear, and triaxial testing are being written.

The California Bearing Ratio method of test for bearing of soils will receive ASTM recognition when the current project is completed. For use on earth dam and embankment projects, a density-in-place test is being developed using the rubber balloon method.

Soil-cement mixtures can now be evaluated for compressive and flexural strength by means of four related methods completed during the year.

Pile load bearing tests under consideration include methods for tests on batter pile frames, lateral load on single vertical piles or anchors, and a pull test of single vertical piles.

SORPTIVE MINERAL MATERIALS

In this new field of materials covered by ASTM, Committee C-23 on Sorptive Mineral Materials is making marked progress in the preparation of methods of sampling, sieve analysis, free moisture and loss on ignition. A number of additional methods in a less well developed stage include the determination of bulk density, absorptive properties, solubility in water, resistance to breakdown in oil, dustiness, slipperiness, resistance to breakdown in water, and fire resistance.

The committee has organized a new subcommittee on performance standards with the general objectives to develop plant evaluation methods for sorptive mineral materials and to use these procedures to verify laboratory test methods.

REFRACTORIES

Interlaboratory work has been completed for the development by Committee C-8 on Refractories of a method of testing the hydration resistance of basic brick magnesite grain, and unoiled dolomite.

Preparatory studies have been completed for the determination of bulk density of hydratable materials. Work has also been completed on methods to determine the reheat change of carbon brick and shapes, testing the size and bulk density of carbon refractories, and for determining the permeability of carbon brick.

A proposed method of test for size and bulk density of insulating fire brick will be presented to the Society at the 1959 Annual Meeting. Other methods to be presented include a method of test for thermal conductivity to test the spalling resistance of silica brick using a hot plate, and revisions to the load test schedules in the method of testing refractory brick under load at high temperatures (C 16 – 49).

CERAMIC WHITEWARES

A method to determine the translucency of fired whiteware materials using a step-wedge specimen is being developed by Committee C-21 on Ceramic Whitewares.

Tests in various stages of completion are a method for particle-size analysis of whiteware clays using the hydrometer technique, a test for alkali durability of glazed surfaces of ceramic whitewares, a test for solubility of lead in glazed surfaces, a quenching test for ceramic tile for measuring crazing resistance, and a revision of the method of test for impact resistance of ceramic tableware (C 368) to account for the toss factor.

PORCELAIN ENAMELS

Data on the anomalous behavior of certain white enamels on iron have been collected by Committee C-22 on Porcelain Enamels. These data form the basis for a revision of the scope of the method of test for adherence of porcelain enamel and ceramic coatings to sheet metal (C 313 – 55), in which it will be stated that the test is not adequate for white-on-iron and also does not apply to enameled aluminum.

ORGANIC MATERIALS, CHEMICAL PRODUCTS

PLASTICS

Whether the abbreviation ABS refers to American Baking Society or acrylonitrile-butadiene-styrene plastic depends on one's point of view. In the plastics field, ABS is one of a number of abbreviations for complicated plastics terms that has been standardized by Committee D-20 on Plastics and published as tentative abbreviations (D 1600 – 58 T). At least this will provide a source to decipher abbreviations which all too often are confusing.

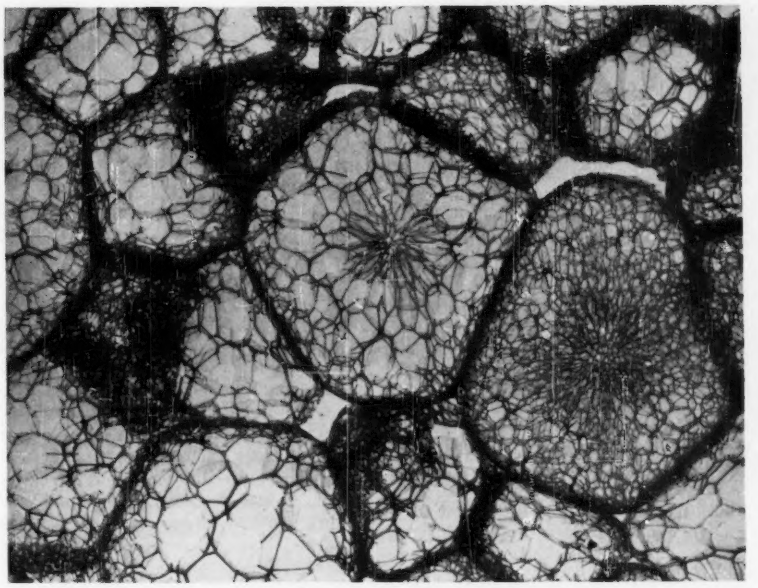
The 1958 output of standards on plastics is considerable. At the 1958 Annual Meeting, 12 new tentatives relating to plastics were approved by the Society.

The Subcommittee on Plastic Pipe, jointly sponsored by ASTM and the Society of the Plastics Industry, completed work on two significant test methods for plastic pipe covering a long-time hydrostatic pressure test (D 1598–58T), and a short-time rupture strength test (D 1599 – 58 T). These tests are going to be very useful for reference in establishing working pressures for plastic pipe for various industrial and domestic piping applications.

During the year 1958, much of the confusion surrounding the grades and types of polyethylene was eliminated with the publication of revised specifications for polyethylene (D 1248). The revision established three general types of polyethylene covering three density ranges. In addition, the three types are further subdivided into several grades according to physical properties.

PAINTS

With the great increase in application of latex and emulsion paints, there has been corresponding extensive activity toward development of standards in Committee D-1 on Paints. The committee is evaluating cooperatively tests for washability, scrubability, freezing-and-thawing stability, and coalescence. Studies are also being made pointed toward development of tests for latex paints for exterior use. Several new and useful methods for measuring color have been developed by the committee, in particular, methods for color difference using the colormaster differential colorimeter (D 1536 – 58 T), method of specifying color by the Munsell System, color change of white architectural enamel (D 1543 – 58 T), and color of transparent liquids (D 1544 – 58 T). The Committee on Paints has active liaison with Committee E-12 on Appearance as well as with Committee D-20 on Plastics. Most of the methods for measuring color of paints may also be used for measuring color of plastics.



Cross-Section of Expandable Polystyrene Bead Foam

Magnification 23 X, reduced for publication. Second Prize, Photomicrographs, Black and White—Fibers; Eleventh ASTM Photographic Exhibit. Ruth Giuffria, General Electric Co., Louisville, Ky.

TEXTILES

With the current interest in materials that will perform at high temperatures, standards for asbestos textiles have been given special attention in Committee D-13 on Textiles. The committee completed work on a method for heat aging of asbestos textiles (D 1573 – 58 T) as well as two specifications covering asbestos tapes and cloth which were published in the committee's annual report. Asbestos textile with little or no cotton as admixture can be used at temperatures as high as 1000 F.

The textile committee has also given attention to improving methods for evaluating rayon, nylon, and polyester tire cords which are to replace methods for rayon tire cords (D 885). Tire cord work is in cooperation with Committee D-11 on Rubber.

ADHESIVES

The interlaboratory work of testing some 960 specimens at four rates of loading has been completed. This study was to determine the effects of rate of loading on the results obtained in the method of test for strength properties of adhesives in shear by tension loading (metal-to-metal) (D 1002). Analysis of the results indicate that the rate effect was negligible.

The climbing drum peel test that has been accepted by government agencies will be presented to the Society for acceptance in June.

A broad spectrum of work for wood adhesives, metal-to-metal adhesives, and adhesives for plastics has been initiated through three new subcommittees organized with both West and East Coast groups. Work of the wood adhesives subcommittee is under way.

RUBBER

Rubberlike plastics in cellular form are increasingly used in automotive seating, in furniture, and in various other applications where its shock absorbing characteristics are useful. The two principal synthetic materials currently used for this purpose are the urethanes and poly(vinyl chloride) plastics. These two materials in cellular form were subjects of specifications and test methods developed by Committee D-11 on Rubber in cooperation with the Society of the Plastics Industry and approved by the Society at the Annual Meeting. The committee has also selected certain definitions of terms from the "Rubber Glossary" (STP 184) and other sources, and has established them as tentative definitions (D 1566). This is the first step toward development of an extensive list of standard definitions of terms relating to rubber and rubberlike materials.

Among the committee's other numerous activities, there is cooperative work with the textile committee on standards for rubber-coated tire cords. Also the committee is developing tests for abrasion resistance of rubber soles and heels.

ASTM IN 1958 . . .

LEATHER

Leather is one of many materials the physical properties of which are greatly influenced by the moisture content, which in turn is affected by the ambient conditions. In order to control the moisture content and the related physical conditions, the joint ALCA-ASTM Committee on Leather has established as tentative a method for conditioning leather and leather products for testing (D 1610). Another method approved at the 1958 Annual Meeting covers corrosion produced by leather in contact with metal. This is an important factor in the case of leather used as packing in hydraulic systems.

The leather committee is also conducting an extensive outdoor test program with the cooperation of General Motors Corp. at its South Florida test site. Altogether, 2808 specimens of four different types of leather will be exposed and evaluated. Fourteen laboratories will participate.

PAPER

A survey of the tests used by the Federal and local governments for flammability of treated paper has been completed. The survey revealed tremendous differences in both methods and apparatus used for the flammability tests. A complete revision of the method of test for flammability of treated paper and paperboard (D 777) is being written in order to standardize this important test.

The wide breaking-time limit permitted in the method of test for tensile breaking strength of paper and paper products (D 828) will be revised to a more realistic value, namely, with the specimen breaking as close to 25 sec as possible. The revision will call for adjusting the machine so that the breaking load will be applied in that time, thus giving results which can be compared directly.

ELECTRICAL INSULATING MATERIALS

Much of the current interest and effort in electrical insulation standards is related to the problem of classifying insulating materials from the point of view of thermal stability. Work is going on both in ASTM Committee D-9 on Electrical Insulating Materials and in the American Institute of Electrical Engineers. The objective is classification of materials on a basis of performance rather than on a basis of composition. A factor which enormously complicates the problem is the interaction of various combinations of materials used in electrical equipment. Therefore much of the effort, particularly in the AIEE, is directed toward the development of tests involving combinations of materials which simulate actual use conditions.

In cooperation with AIEE, Committee D-9 is developing tests both for insulating material alone and for simple combinations of materials. In all this work, the objectives of temperature classification, as outlined by the AIEE, are kept in mind and the effort is toward establishing suitable tests for insulating materials that will be useful in classifying materials. Of course, Committee D-9 is also developing tests for specification purposes, the requirements of which are often quite different from the problems of classification for thermal stability. As evidence of activity in thermal stability tests, the committee published in its Annual Report two suggested methods for thermal stability of coated fabrics, one involving a dielectric proof test and the other dielectric breakdown. The committee has also drafted a method for thermal stability of laminated plastics.

PETROLEUM PRODUCTS

The very extensive activities of Committee D-2 on Petroleum Products and Lubricants were reported in the October issue of the ASTM BULLETIN, p. 22. Outstanding in the committee work during the year was the completion of several symposium publications, including:

- Composition of Petroleum Oils, STP 224.
- Knock Characteristics of Pure Hydrocarbons, STP 225.
- Railroad Materials and Lubricating Oils, STP 214.
- Steam Turbine Oils, STP 221.
- Vapor Phase Oxidation of Gasoline, STP 202.
- Stability of Distillate Fuel Oil, STP 244.

In its Annual Report, the committee recommended approval of 7 new tentative methods and 4 new standard methods. Of particular interest are the ASTM butadiene measurement tables (D 1550) which are used for the calculation of quantities of butadiene. The establishment of these tables as tentative follows from the transfer of synthetic rubber facilities from the Government to private ownership several years ago. Committee D-2 has taken over part of this program as it refers to butadiene. Other parts of the program are carried by Committee D-16 on Aromatic Hydrocarbons and Committee D-11 on Rubber.

AROMATIC HYDROCARBONS

An infrared spectrophotometric method for isomers in nitration grade xylene will be presented for publication as information. Methods for testing styrene polymer content, polymer solubility, viscosity, inhibitor content, and color are being developed. The determination of water content of refined phenol by the Karl Fischer method will be presented to the Society at the 1959 Annual Meeting.

Other projects in various stages of completion include a method of detecting trace amounts of chlorine and sulfur, a determination of traces of thiophene in benzene, and an acid wash test for benzene.

ENGINE ANTIFREEZES

The study of a method to determine the foaming tendencies of engine antifreezes has shown a wide variation in the results of cooperative tests. Work will continue on the revision of the draft method.

A revision of the method of testing for water in concentrated engine antifreeze by the iodine reagent method (D 1123) will explain precautions necessary due to interference by inhibitors in the antifreeze formulation.

NAVAL STORES

A test to determine the softening point of rosin is being developed. Further interlaboratory testing is under way to refine the method of test for fatty acids content of tall oil rosin (D 1585).

WAX POLISHES

Methods for extracting abrasives from and determining water in prewax auto cleaners and polishes are being presented for committee action. The interlaboratory testing of a method for determining total solids of solvent type waxes will be started again using an aluminum moisture dish as standard.

Work on the complex features of slip resistance of applied floor waxes is continuing.

A second interlaboratory collaborative test to determine whether an oven test (125 F) procedure is an adequate measure for defining stability characteristics was presented to the committee. The method seems to hold promise and will be presented to the committee for action.

CASEIN AND OTHER PROTEINS

Methods for the determination of nitrogen and moisture in casein and soya protein are being prepared for committee action. Interlaboratory studies are under way for the determination of particle size, viscosity of casein solutions, insoluble material, odor of the dry casein and slurries, the minimum alkali requirement, and adhesive strength of casein and soya proteins.

TESTING AND ANALYSIS

COAL AND COKE

Sampling procedures have occupied a large portion of the energies of Committee D-5 on Coal and Coke for the past eight years. The culmination of this work, which is in draft form, covers standard methods for preparing coal samples from the gross sample. The new method is under intensive interlaboratory study. A method for preparation of coal samples for laboratory analysis in the mill and a draft method of sampling coke are being developed.

Interlaboratory studies of procedures for determining mineral carbonate in coal, sulfur in coal ash, total sulfur, forms of sulfur, and chlorine content are continuing.

SHIPPING CONTAINERS

A compilation is being made of the essential dimensions of the existing installations of inclined impact machines (Conbur Tester) to determine the variations in the machines now in use. Electronic instrumentation has also been used to determine what acceleration levels were obtained on these machines. When these data are available, a new method will be written to replace the method of incline impact test for shipping containers (D 880).

The dynamic tests for package cushioning materials are ready for presentation to the Society. These tests will be in addition to the static tests now found in methods of testing package cushioning materials (D 1372).

An interlaboratory study based upon a procedure for the determination of the compatability of packaging materials with metals is in progress.

INDUSTRIAL WATER

A highlight of 1958 in the activities of Committee D-19 on Industrial Water was the Symposium on Radioactivity at the Annual Meeting. Any appreciable amount of radioactivity in the water used as a heat transfer medium in water-cooled nuclear reactors is objectionable. It was brought out at the symposium that purity requirements for primary water in reactors must be extremely high in order to minimize build-up of radioactivity and to reduce maintenance problems. It is therefore necessary to analyze for constituents in extremely small amounts, and a whole new set of procedures for sampling and analysis must be developed.

Methods for dissolved gaseous hydrogen (D 1588) and for dissolved oxygen (D 1529) were approved by the Society at the Annual Meeting. Also approved were methods for effect of water in tubular heat exchangers (D 1591) and surface tension of water (D 1590).

ATMOSPHERIC ANALYSIS

Committee D-22 on Atmospheric Analysis culminated several years work in 1958 with the approval by the Society of five methods and recommended practices. Methods covered determination of nitrogen oxides, oxidant content and inorganic fluorides in the atmosphere, and a recommended practice for sampling atmospheres for gases and vapors.

Members of the committee have been active participants in a number of national conferences on air pollution and there is no question but that the committee is making worth-while contributions toward air pollution control which is becoming a major problem in many cities.

METHODS OF TESTING

A significant action of coordination and consolidation was the establishment as standard of specifications for distillation equipment (E 133) by Committee E-1 on Methods of Testing. The new specification consolidates and simplifies the equipment used in a number of distillation methods for petroleum, for gas oil and fuel oils, for gasoline, for plant spray oils, for aromatic hydrocarbons, and for lacquer solvents and diluents. Another significant action of the committee was the establishment of a method for determining Poisson's ratio (E 132). Using data from tension tests of structural materials, the method enables determination of Poisson's ratio for specimens of rectangular cross-section in which creep is negligible compared to the strain produced immediately upon loading.

SPECTROSCOPY AND CHEMICAL ANALYSIS

In 1958 the Society published the first group of 23 definitions of terms applying to the field of emission spectroscopy. Definitions are always an important part of the Society's work, as they provide standard means for communicating information.

Committees E-2 on Emission Spectroscopy and E-3 on Chemical Analysis of Metals are both actively developing standards for materials of interest in the nuclear field, including zirconium, columbium, lithium, and thorium. This activity relates to the work in Committee B-2 on Non-Ferrous Metals toward the development of standards for these materials.

In 1958 the Society issued what is probably the first of a series of standard methods relating to fire-refined copper—a method for determining arsenic (E 62).

Determination of rare earths is another first, embodied in the methods for chemical analysis of magnesium and alloys (E 35), approved at the 1958 Annual Meeting. The methods cover, in addition to rare earths, determination of zirconium and thorium.

During 1958 Committee E-13 on Absorption Spectroscopy continued to increase the number of chemical compounds for which absorption spectra, both infrared and ultraviolet, are available on punched cards. The infrared spectra comprise altogether 18,584 punched cards; the total ultraviolet spectra cards comes to 10,935. These cards offer the most complete reference data on absorption spectra available anywhere.

Committee E-13 on Absorption Spectroscopy plans to issue a group of cards covering the near infrared. Later, the visible range will also be covered. Other new projects of the committee cover molecular resonance spectroscopy such as nuclear magnetic resonance and fluorescence spectroscopy. Initiation of these new projects followed symposiums on these subjects held in conjunction with the meeting in November, 1958, of the Society for Applied Spectroscopy.

In the past it has been necessary to refer to trade names of spectrophotometers in methods employing spectroscopy. In order to provide information on the performance of spectrophotometers so that this factor could be referenced in spectrographic methods, Committee E-13 on Absorption Spectroscopy published in its Annual Report a proposed method for evaluation of spectrophotometers. It is expected that this method will be recommended as tentative after a period of use.

MASS SPECTROMETRY

With a similar objective, Committee E-14 on Mass Spectrometry has published as tentative a recommended practice for evaluation of mass spectrometers for use in chemical analysis (E 137). This recommended practice will provide a reference for other analytical methods employing this technique.

The Sixth Annual Meeting of Committee E-14 on Mass Spectrometry was held in New Orleans in June, 1958. The program, consisting of nine sessions in five days, included 62 technical papers covering a great variety of subjects related to mass spectrometry.

Papers from the week-long meeting were not published as a group, although abstracts were available at the meeting and individual papers will appear in various technical and scientific journals.

NEW ASTM PUBLICATIONS

Progress on 1958 Book of ASTM Standards

Presswork has now been completed on Parts 1, 2, 3, 4, and 9. Parts 2, 4, and 9 have been distributed and, as this BULLETIN goes to press, Parts 1 and 3 are being distributed to all who have requested them. These books will be followed shortly by Parts 10, 7, 6, 5, and 8, in that sequence.

WARNING! Part 3 Plates Must be Requested

WHEN the 1958 Book of Standards was set up to include in Part 3 the methods of test for metals (excluding chemical analysis), it was found that the many insert plates formerly appearing in Parts 1 and 2 would all appear in Part 3. This caused a serious problem in binding. The inclusion of so many inserts would "break the back" of the book and make for a very unsatisfactory binding. Therefore, after careful consideration, it was determined that the best interests of all concerned would be fulfilled by making these insert plates available free of charge to those getting Part 3, utilizing the request coupons printed in the back of the book. Members and buyers of Part 3 who wish to receive these insert plates may do so simply by clipping the coupons, addressing them according to instructions, and forwarding them to Society Headquarters. No other means of obtaining these plates without charge can be recognized.

This notice is published largely to prevent an unsuspecting member from being "surprised" when he reaches for Part 3, searches for a plate, and finds that it has to be ordered. By requesting the insert plates he needs as soon as he receives Part 3 he will have the plates on hand when needed.

Petroleum Products and Lubricants

Compilation of Standards, D-2

THIS compilation contains most of the ASTM Standards on petroleum products and lubricants. Many revisions are included, as well as 7 new tentative standards. In addition 15 proposed standards published for information only are included.

This edition supersedes the November, 1957, edition. It is designed for ready reference and has proved its value over the years as revised editions have appeared.

Petroleum chemists and technologists; aircraft, railway, and industrial engineers; purchasing agents and sales engineers find this compact, convenient volume handy in their daily work.

ASTM Standards on Petroleum Products and Lubricants, 1074 pages, hard cover, price $8.25, to members, $6.60.

Soaps and Other Detergents

Compilation of Standards, D-12

THIS volume contains 40 standards, 11 of which are new, revised, or have had their status recently changed. Three of the new methods cover tests for synthetic detergents and represent a significant addition to the coverage provided by the methods in this compilation. Alkylbenzene sulfonates, detergent alkylate, and fatty alkyl sulfates are now covered in addition to the previously good coverage of soaps, alkaline detergents, metal cleaners, and the like. The compilation, sponsored by Committee D-12 on Soaps and Other Detergents, should prove useful to commercial laundries, metal cleaners, and all concerned with the manufacture or use of cleaning materials.

ASTM Standards on Soaps and Other Detergents, 256 pages, paper cover, price $3.50, to members $2.80.

Symposium on Radioactivity in Industrial Water and Industrial Waste Water

THE advent of nuclear power has brought new problems to the field of industrial water techniques. In this symposium problems in the reactor plant itself and in the associated waste water are discussed. Methods of analysis for radionuclides in industrial water are described, including a discussion of radiation hazards. Detailed consideration has been given to the special problems associated with determination of extremely low amounts of certain constituents in the high-purity water required in nuclear power plants, to the necessity for measurements of radioactivity of water, and to evaluation of the type and amount of by-products being released in waste water. These timely discussions should provide water technologists, utilities engineers, and others concerned with radioactivity with interesting and up-to-date data on the subject. Papers included are:

Introduction—A. R. Belyea.
Radioactivity and Purity Control of APPR Primary Water—A. Louis Medin.
Radioactive Waste Processing Control, Shippingport Atomic Power Station—S. F. Whirl and J. A. Tash.
Test Methods for Radioactivity Hazards in Industrial Waters—C. J. Munter.
Analysis for Radionuclides in Aqueous Wastes from an "Atomic" Plant—B. Kahn, D. W. Moeller, T. H. Handley, and S. A. Reynolds.
Analysis of Environmental Samples of Radionuclides—D. L. Reid.
Analysis of Radioactivity in Surface Waters—Practical Laboratory Methods—L. R. Setter, G. R. Hagee, and C. P. Straub.
Summation—J. M. Seamon.

STP235, 76 pages, hard cover, price $2.50, to members $2.00.

Bituminous Materials for Highway Construction, Waterproofing, and Roofing

Compilation of Standards, D-4, D-8

INCLUDED in this compilation are 115 standard specifications, methods of test, recommended procedures, and definitions. Of these 31 are new, revised, or have had their status changed since the previous edition in 1957.

Significant additions to the compilation in the form of new tentatives are methods of testing bituminous road mixtures, these including: Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of the Hveem Apparatus; Resistance to Plastic Flow of Bituminous Mixtures; and Preparing Bituminous Mixtures by Means of the

California Kneading Compactor.

This volume, together with its companion compilation "Mineral Aggregates and Concrete" should prove invaluable to highway engineers, state highway departments, and others concerned with the national highway program. Builders, architects, and others concerned with roofing and waterproofing will find this compilation extremely useful in their work.

ASTM Standards on Bituminous Materials for Highway Construction, Waterproofing, and Roofing, 488 pages, paper cover, price $4.75, to members $3.80.

Symposium on Electron Metallography

AMONG the 11 papers presented in this symposium, metallurgists, spectroscopists, and engineers will find many new and comprehensive techniques for the study of materials through the use of the electron microscope. When first organized under ASTM auspices, only the electron microscope study of steels was contemplated. The use of this laboratory tool has expanded quite rapidly. Now, non-ferrous metals and the superstrength alloys are also being studied. Papers included are:

Introduction, Summary—N. A. Nielsen.

Techniques Employed in the Electron Microscope Study of Titanium Alloy with 8 per cent Manganese—First Progress Report of Non-Ferrous Task Group of Subcommittee XI on Electron Microstructure of Metals.

Vibratory Polishing of Specimens for Electron Microscopy—E. L. Long and R. J. Gray (abstract only).

A Technique for Easy Removal of Direct Replicas for Electron Microscopy—W. H. Bridges and E. L. Long, Jr.

Examination of Metals by Transmission Electron Microscopy—F. W. C. Boswell and E. Smith.

A Study of Dislocations in Thin Aluminum Foils Elongated in the Electron Microscope—H. G. F. Wilsdorf.

Microstructure of Age-Hardenable Alloys—J. R. Milhalisin and K. G. Carroll.

An Electron Metallographic Study of the Precipitation-Hardening Process in Commercial Nickel-Base Alloys—W. C. Bigelow, J. A. Amy, C. L. Corey, and J. W. Freeman.

The Application of Electron Diffraction and Electron Microscopy in Studies of Minor Phases of Heat-Resistant Alloys—W. C. Bigelow, L. O. Brockway, and J. W. Freeman.

Electron Probe Analysis of Segregation in Inconel—L. S. Birks and E. J. Brooks.

Selected Etchants for Electron Microscope Studies of Magnesium Alloys—C. A. Moe.

STP245, 126 pages, hard cover, price $4.00, to members $3.20.

Papers to Appear in Future Issues of the ASTM Bulletin

An Improved 8-Hydroxyquinoline Method for the Determination of Magnesium Oxide in Portland Cement by H. A. Berman, National Bureau of Standards.

A New Method for Determining the Wet Adherence of Supported Films to Various Substrata by A. S. Diamond, Eastman Kodak Co.

A Modified Apparatus for Measuring the Vicat Heat Distortion Temperature of Plastics by G. F. L. Ehlers, Wright Air Development Center.

Further Development and Use of the Armstrong Sandpaper Abrasion Machine by F. M. Gavan, Armstrong Cork Co.

Release of Alkalies by Sands and Admixtures in Portland Cement Mortars by W. C. Hansen, Universal Atlas Cement Co.

The Determination of Alkyl Aryl Sulfonates by Ultrasonic Absorption by R. M. Kelley, E. W. Blank, and W. E. Thompson, Smith, Kline and French Laboratories.

Analysis of Commercial Sodium Tripolyphosphate by Reverse Flow Ion Exchange Chromatography by R. H. Kolloff, Monsanto Chemical Co.

The Sucrose Extraction Method of Determining Available Calcium Oxide in Hydrated Lime by D. R. Moorehead and W. H. Taylor, Commonwealth Scientific and Industrial Research Organization.

Physical Changes in Setting Plaster by B. M. O'Kelly, National Research Council of Canada.

An Improved and Semi-Automatic Method of Conducting the Standard Hardness Test for Timber by A. P. Schniewind, University of California.

An Instrument for the Measurement of Pore-Size Distribution by Mercury Penetration by N. W. Winslow, Prado Laboratories, and J. J. Shapiro, Land Air, Inc.

Should Statistical Methods be Used to Prepare Materials Specifications by H. R. Sheppard and H. Ginsburg, Westinghouse Electric Corp.

The Theory of Extreme Values by J. Mandel, National Bureau of Standards.

Inside ASTM Free Literature

To answer the questions and needs of ASTM members and prospective members, the Society publishes numerous manuals, lists, and pamphlets about specific activities of the Society. Many of these are sent annually to members. Copies of the following publications may be obtained from the American Society for Testing Materials, Development Dept., 1916 Race Street, Philadelphia 3, Pennsylvania. Except where noted, single copies are free upon request.

Annual Report of the Board of Directors.

Index to ASTM Standards. About 240 pp. Issued annually and sent to members and purchasers of the Book of ASTM Standards.

List of ASTM Standards. 80 pp. Standards grouped by field of activity.

List of Special Technical Publications, Compilations, Symposiums or Topical Discussions. 1898–1956. 20 pp.

List of ASTM Publications. 32 pp. Catalogs all current publications; sent annually to members.

Folder describing 1958 Book of ASTM Standards.

ASTM and You. Describes the Society's activities and membership benefits; includes membership application form. Excellent for encouraging membership among your interested associates.

ASTM—Benefits of Sustaining Membership.

The Engineering Student and ASTM.

So Now You Are a Committee Member. Booklet describes committee operation and role of the committee member. A copy is sent to each member and committee member.

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"East is East and West is West . . ."

Rudyard Kipling said it first: "East is East and West is West, and never the twain shall meet." The quotation could not be used today, however, to describe the activities of ASTM in this country. On the contrary. In recent years, interest and activity on the part of West Coast members in ASTM committee work has grown rapidly. As a result, East and West Coast groups have been moving closer together through research and standardization work in the Society.

This is not to say that there has not been for years representation on many important committees from Western industries and groups. There have been the Hannas, the Weintzes, the Garins, the Dressers, the Tuemmlers, the Mays, the Davises, the Prices, and many like them who have traveled many thousands of miles to take a very constructive part in the work of committees concerned with such key materials as cement, concrete, petroleum, steel, plastics, and wood.

As an example of increasing activity in the West, a subcommittee of Committee D-20 on Plastics sponsored a very successful session on reinforced plastics during the 1956 Pacific Area Meeting in Los Angeles. The objective of this meeting, to develop more interest and participation in this work, was very effectively fulfilled. Also, a new subcommittee on wood adhesives of Committee D-14 is organized into two groups: East Coast and West Coast.

Ever since the first Pacific Area Meeting in 1949, members of the ASTM Staff, in their travels through the West, have successfully endeavored to arouse the interest of increasing numbers of leading technical men in participation in the work of the Society. These men have recognized that the voice of the West should be heard in our research and standards activities.

Our Board of Directors is scheduling an increasing number of national meetings in the West. Our first national committee week west of the Mississippi was held in St. Louis in February, 1958; the Third Pacific Area Meeting (these are now held about every three years) will be in San Francisco in October, 1959; in 1962, the Spring Meeting is to be held in Dallas, Tex. Meanwhile, as might be expected, the center of gravity of membership in the United States gradually moves west, reflecting the growing numbers of Western individuals and companies in our Society.

Thus East and West are moving closer together in ASTM. It must be a point of considerable satisfaction to the many members from the Far West who, through many years in the past, have made the long trek from their businesses and homes to attend meetings of the Society in the East. To them, the Society owes a debt of gratitude for their continued support. It is to be hoped that the increasing number of meetings scheduled for the West may be a partial payment of that debt.

R.J.P.

25-Year ASTM Members 1934-1959

Aloe, A. S., Co.
Aluminum Industries, Inc.
American Oil Co.
American Society of Agricultural Engineers
Angel, Charles Mowbray
Antioch College Library
Association of Edison Illuminating Cos.
Australia, Commonwealth Scientific and Industrial Research Organization
Beasley, Milton R.
Besozzi, Leo
Brust, Alvin W.
Campus, F. A. A.
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Cone, Russell G.
Crone, Alfred F.
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Evans Pipe Co., The
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Fraser, H. M.
General Radio Co.
Gingrich, Earl S.
Gogan, Joseph
Gruse, W. A.
Harrison Radiator Division, General Motors Corp.
Honolulu Board of Water Supply
Housel, William S.
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Kosting, Peter R.
Los Angeles, County of, Road Dept., Testing Laboratory
Lotz, P. L.
McCoy, John T.
Menzel, Carl A.
Michigan-Standard Alloy Casting Co., Division of Consolidated Foundries and Manufacturing Corp.
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Sipe and Co., James B.
Sisler, Samuel
South Florida Test Service, Inc.
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Tata Iron and Steel Co., Ltd., The
Tennessee Valley Authority, Technical Library
Textor, Ralph B.
Turnbull, Edward D.
United Carbon Co., The
United States Rubber Co.
Vickers, G. W.
Vose, Robert W.
Weesner, Carl W.
Widdell, H. E.
Wright, Frank L.

Committee Week in Pittsburgh

Symposium on Testing of Window Assemblies . . . Dinner and Luncheons

Problems of engineering materials for the defense program, for research, for industry, and for better living will be considered at some 350 technical committee meetings during the Society's Committee Week at the Penn-Sheraton Hotel, Pittsburgh, February 2 to 6, 1959.

In addition to the work of the technical committees, there will be a technical session comprising a symposium on the testing of window assemblies, sponsored by Committee E-6 on Methods of Testing Building Constructions.

John C. Warner, President of Carnegie Institute of Technology and Consultant to the U. S. Delegation to the Second U. N. International Conference on the Peaceful Uses of Atomic Energy at Geneva, will be the guest of honor and speaker at a dinner to be held Wednesday, February 4.

Interested visitors will be welcome to attend the symposium, the luncheons, and the dinner whether or not they are members of the Society. Most of the committees will also welcome interested visitors. It is suggested that visitors introduce themselves to the chairman or secretary and inform them of their interest in the work of the committee.

The Pittsburgh District Council under the chairmanship of J. R. Romualdi, assistant professor of civil engineering at Carnegie Institute of Technology, with the assistance of Vice-Chairman E. J. Holcomb, Aluminum Company of America, and Secretary A. S. Orr, Gulf Oil Corp., is planning the Committee Week dinner and the social hour preceding it. M. D. Baker, West Penn Power Co., and C. H. Sawyer, Eastern Gas and Fuel Associates, are serving as the Finance Committee.

Symposium on Testing Window Assemblies

In addition to the committee activities, there will be a symposium on Testing Window Assemblies sponsored by Committee E-6 on Methods of Testing Building Constructions. The tentative list of papers to be presented follows:

Considerations in Evaluating Factory Sealed Double Windows—A. Grant Wilson and K. R. Solvason, National Research Council of Canada.

Practical Test Experience with Certain Aspects of Glass Performance—C. R. Frownfelter, Pittsburgh Plate Glass Co.

Structural Aspects and Operations of Windows—E. M. Lurie, Veterans Administration.

Norwegian Test Methods for Rain Penetration Through Windows—Norwegian Building Research Inst.

Need for Research and the Development of Test Methods for Windows—L. M. Dunn, Aluminum Company of America.

This symposium, being arranged under the chairmanship of R. B. Crepps of Purdue University, is intended to fill an indicated need for information of this kind for use by the construction industry.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
February 1–6	Committee D-2 on Petroleum Products and Lubricants	St. Louis, Mo. (Sheraton-Jefferson Hotel)
February 2–6	**Committee Week**	**Pittsburgh, Pa. (Penn Sheraton Hotel)**
February 4–6	Committee D-16 on Industrial Aromatic Hydrocarbons and Related Materials	St. Louis, Mo. (Sheraton-Jefferson Hotel)
February 16–18	Committee D-9 on Electrical Insulating Materials	Washington, D. C. (Sheraton Park Hotel)
February 18–20	Committee D-20 on Plastics	Washington, D. C. (Sheraton Park Hotel)
February 19	Organization meeting of Committee E-15 on Analysis and Testing of Industrial Chemicals	Philadelphia, Pa.
February 25	Southwest District	Houston, Texas
February 25	Philadelphia District	Philadelphia, Pa. (Franklin Inst.)
February 25	Committee B-4 on Metallic Materials for Electrical Heating, Electrical Resistance and Electrical Contacts	Washington, D. C. (Mayflower Hotel)
February 26–27	Committee D-6 on Paper and Paper Products	New York, N. Y. (ASA Headquarters)
February 26	Southwest District	Houston, Texas
February 26–27	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Washington, D. C. (Mayflower Hotel)
March 2	Southwest District	College Station, Texas (Texas A. & M.)
March 2	Committee E-13 on Absorption Spectroscopy	Pittsburgh, Pa. (Penn Sheraton Hotel)
March 3	Southwest District	Dallas, Texas (Southern Methodist Univ.)
March 4	Southwest District	Norman, Okla. (Oklahoma Univ.)
March 6	Rocky Mountain District	Salt Lake City, Utah (University of Utah)
March 9	Southern California District	Los Angeles, Calif. (Roger Young Auditorium)
March 10	Northern California District	San Francisco, Calif.
March 11	Northern California District	Berkeley, Calif. (University of Calif.)
March 17–19	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)
April 3	Committee E-12 on Appearance	New York, N. Y.
April 5–10	Fifth Nuclear Congress	Cleveland, Ohio
April 13–14	Committee D-15 on Engine Antifreezes	Washington, D. C. (Shoreham Hotel)
April 13–14	Committee D-10 on Shipping Containers	Chicago, Ill.
April 29	Detroit District	Detroit, Mich.
April 30	Pittsburgh District	Pittsburgh, Pa.
May 18–22	Committee E-14 on Mass Spectrometry	Los Angeles, Calif. (Statler Hotel)
May 21	D-21 on Wax Polishes and Related Materials	Chicago, Ill.
June 21–26	**Annual Meeting**	**Atlantic City, N. J. (Chalfonte-Haddon Hall)**
October 11–18	**Third Pacific Area National Meeting**	**San Francisco, Calif. (Sheraton-Palace Hotel)**

Annual Meeting Program Taking Shape

So far, 9 Symposiums are planned for the 1959 Annual Meeting to be held at the Chalfonte-Haddon Hall in Atlantic City, N. J., the week of June 21–26. Additional sessions on metals, high temperature, fatigue, road and paving materials, etc., are also scheduled. The April issue of the ASTM BULLETIN will carry the complete detailed program of the meeting. A partial preview of symposiums and sessions follows:

SYMPOSIUMS

Practical and Statistical Significance of Tests and Properties of Bituminous Binders
Sponsored by Committee D-4 on Road and Paving Materials

Methods of Test for Design of Bituminous Paving Mixtures
Sponsored by Committee D-4 on Road and Paving Materials

Atterberg Limits
Sponsored by Committee D-18 on Soils for Engineering Purposes

Time Rate of Loading in Soil Testing
Sponsored by Committee D-18 on Soils for Engineering Purposes

Identification of Water-Formed Deposits
Sponsored by Committee D-19 on Industrial Water

Microscopy
Sponsored by Committee E-1 on Methods of Testing

Spectroscopic Light Sources
Sponsored by Committee E-2 on Emission Spectroscopy

New Visual Aids for Standardizing and Communicating Product Appearance
Sponsored by Committee E-12 on Appearance

Engineering Education in Materials
Sponsored jointly by American Society for Engineering Education and ASTM

SESSIONS

Cement
Sponsored by Committee C-1 on Cement

Concrete
Sponsored by Committee C-9 on Concrete and Concrete Aggregates

Road and Paving
Sponsored by Committee D-4 on Road and Paving Materials

Soils
Sponsored by Committee D-18 on Soils for Engineering Purposes

National Conference on Standards

The Society participated in the very successful National Conference on Standards held under the auspices of the American Standards Assn. in New York City in November.

At the invitation of the ASA, the Society sponsored a session on standard methods and specifications. Various aspects of the subject and fields of materials were covered. President K. B. Woods stressed the interrelationship between standards and research, citing a number of instances where considerable research was needed before standards could be prepared. Paul A. Archibald, chief metallurgist of Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., called attention to the use of specifications so the steelmaker and user might speak a common language. I. V. Williams of Bell Telephone Laboratories gave the viewpoint of the user with respect to the availability of standard specifications. From his long experience in committee work he emphasized the need for active consumer participation. He urged all consuming companies to participate in standardization work: even the smaller companies could participate by concentrating their efforts in one committee. S. A. Rosecrans of Westinghouse Electric Corp. also discussed the question of the significance of standards to the consumer. A. C. Webber of E. I. du Pont de Nemours & Co., Inc., covered the subject of standards for plastics from a very broad point of view, including intersociety cooperation and participation in international standardization work.

The session was under the chairmanship of F. L. LaQue, senior vice-president of the Society. From his long association with the work he was able to give the entire session a unity so that a sense of significance of this standardization work was left with those attending.

The proceedings of the entire conference will be available through the ASA in the near future. This will include not only the papers of this session but the many other interesting addresses and papers presented throughout the conference.

Speakers at the session sponsored by ASTM on "Standard Methods and Specifications—Foundations for Standardization in Industrial Operations" held at the 9th National Conference on Standards, New York City. Left to right: Paul A. Archibald, ASTM Director and Chief Metallurgist, Standard Steel Works Division, Baldwin-Lima-Hamilton Corp., Burnham, Pa.; Alfred C. Webber, ASTM Director and Senior Supervisor, Experimental Station, Polychemicals Dept., Research Division, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.; S. A. Rosecrans, Assistant Manager, Materials Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.; I. V. Williams, Metallurgist, Bell Telephone Laboratories, Murray Hill, N. J.; Robert J. Painter, ASTM Executive Secretary; K. B. Woods, ASTM President and Head, School of Civil Engineering, Purdue University; Frank L. LaQue, ASTM Vice-President and Vice-President and Manager, Development and Research Division, The International Nickel Co., Inc., New York, who was presiding officer at the session.

International Student-Industry Program Aids Understanding of U.S. Abroad

A PLAN for foreign students to work in U. S. industry during the summer, as well as for U. S. students to work abroad, is growing in popularity as a means of training students in other countries' industrial techniques and to foster international understanding and good will. The program under the auspices of the International Association for the Exchange of Students for Technical Experience (IAESTE) works like this:

1. Carl Johnson, a 21-year-old Swedish student of mechanical engineering at the Royal Institute of Technology in Stockholm, applies to the Swedish IAESTE Committee. He wants to train with an American company. His application is endorsed by the Royal Institute.
2. The Swedish IAESTE Committee sends Mr. Johnson's application, along with those of other recommended Swedish students, to the IAESTE Committee in the United States (Institute of International Education in New York).
3. The IAESTE Committee in the U. S. contacts Corporation X which has offered to accept a trainee in mechanical engineering. The Committee sends Corporation X a description of Mr. Johnson's qualifications.
4. Corporation X accepts Mr. Johnson as a summer trainee.
5. Mr. Johnson comes to the United States, paying his own travel expenses. The committee assists him in making travel plans, getting a visa, and obtaining insurance.
6. Mr. Johnson works for Corporation X as an on-the-job trainee for a minimum of 8 weeks. Corporation X pays him a maintenance allowance sufficient to cover his living expenses.
7. Mr. Johnson returns to Sweden, paying his travel expenses, with increased technological skills and a broader understanding of America and its people.

U. S. students, wishing to participate in the program abroad, may get applications from the IAESTE Advisor on campus. U. S. companies may obtain further information by writing to the Institute of International Education, Inc., 1 East 67th St., New York 21, N. Y.

Apology

In the December, 1958, issue of the ASTM BULLETIN appeared the paper, "A Note on the Effect of Pressurization on the Fatigue Life of Metals." The author of this paper is Mr. L. W. Hu, Associate Professor of Engineering Mechanics, The Pennsylvania State University. Through an oversight on our part, the photograph of Mr. Hu was not included with the paper. We include it herewith, with our apologies.

L. W. HU

International Cooperation Administration Sponsors Visit

A team of nine Spanish engineers, architects, and construction specialists visited ASTM Headquarters on November 12 while on a study tour sponsored by the International Cooperation Administration. In its six-week visit to the United States the team visited 19 cities and nine states, with the primary interest of studying new materials that would be of interest to the Spanish building and construction industry.

During a 2-hr conference at Society Headquarters with members of the Headquarters Staff, the team was given a general picture of ASTM activities with special emphasis on the work of the Society in the building materials field.

In the photograph, standing left to right: Ramon Vazquez, Consultant Architect, National Institute of Industry, and David G. Webb, Jr., Training Program Officer, International Housing Service, U. S. Housing and Home Finance Agency, who accompanied the team. Seated clockwise around the table from the left: Jose-Angel Carrion, Architect, Central Bureau, National Housing Inst.; Jose Antonio Corrales, Architect; Jose-Antonio Arenillas, Technical Director, Ceramex, S.L.; Jose Maria Yturriaga, Architect; Jose Siles, Interpreter; L. C. Gilbert, ASTM Staff; Manuel Gabiola, Master Builder; Ricardo Ribas, Architect; Jose Maria Garnica, Second Engineer of National Corporation of Roads, Channels, Harbours; and Jose de Aguirre, Provincial Supervisor of Construction.

Printing Errors in 1958 Book of ASTM Standards, Part 9

Two typographical errors have been discovered in Part 9. The first is in the Recommended Practice for Nomenclature for Synthetic Elastomers and Latices (D 1418 - 58 T), on p. 1819. At the end of Section 3 (Elastomers and Rubbers), the letter "U" should be inserted before the last item in the list, so that the item reads:

U—Elastomers having carbon, oxygen, and nitrogen in the polymer chain.

There is also an error in the Method of Test for Tensile Properties of Plastics (D 638 - 58 T), which appears on p. 321 of Part 9, and on the same page in the 1958 compilation, "ASTM Standards on Plastics." In the formula in Section 10(*g*), the exponent on $\bar{X}$ should be changed from a 3 to a 2, so that the formula reads:

$$s = \sqrt{\frac{\Sigma X^2 - n\bar{X}^2}{n - 1}}.$$

District Activities

In Attendance at Purdue Meeting

(Left to right) R. J. Painter, executive secretary, ASTM; K. B. Woods, head of the School of Civil Engineering, Purdue University, and president, ASTM; S. R. Wallace, U. S. Pipe & Foundry Co., and chairman of Chicago District Council; W. H. Price, U. S. Bureau of Reclamation, Denver, and chairman of Committee C-9; and M. N. Clair, president of Thompson & Lichtner Co., and ASTM director.

CHICAGO

ASTM—Democracy in Action Subject of Purdue Meeting

What has been called by several members one of the finest luncheon meetings they ever attended was held at the Purdue University Memorial Union in Lafayette, Ind., on Wednesday, December 3. This featured an address by ASTM Vice-President Dr. A. Allan Bates, vice-president of Research and Development, Portland Cement Association, on the subject "ASTM—Democracy in Action." Also on the program was a short pertinent talk on undergraduate engineering curricula by Dr. Reinhardt Schuhmann, Head, Metallurgical Engineering Dept., Purdue University. Executive Secretary Robert J. Painter spoke briefly on ASTM's interest in engineering education and the active programs the Society is developing in this area.

There were almost 200 at the meeting, including most of the members of Committee C-1 on Cement, and C-9 on Concrete and Concrete Aggregates, but also a good representation from the Chicago District, including the three top officers, Messrs. S. R. Wallace, U. S. Pipe and Foundry Co., *chairman;* K. R. Parker, Joslyn Mfg. & Supply Co., *vice-chairman;* and C. S. Macnair, Acme Steel Co., *secretary*, along with a number of University officials and representatives of industrial management. The head of virtually every engineering college at Purdue attended.

The meeting in a sense was a tribute to the Society's President, K. B. Woods, Head, School of Civil Engineering, at Purdue, who with his associates, acted as host for the technical committee meetings. Professor Woods presided at the luncheon.

Dr. Bates' talk was extremely interesting and stimulating and surely gave every ASTM and committee member present a feeling of pride in the Society. His talk, based on the famous oration by Pericles dealing with democracy, pointed out the counterparts in the ASTM theory and practice with the important principles set forth by the famous Greek statesman. Dr. Bates emphasized how closely the ASTM organization followed the Periclean precepts. It was natural in this context that the responsibility of the individual to the whole organization was stressed.

Dr. Schuhmann, even with a time handicap, drove home two or three essential points in connection with the involved matter of undergraduate engineering curricula. The terrific problem of trying to give the undergraduate sufficient information and training on so many different subjects might be considered almost insurmountable, and perhaps we shall come rapidly to a realization that the most important thing underlying any of the curricula is to teach the undergraduate how to learn and think. He referred to the wider base of engineering training involving more mathematics, physics, and chemistry, which seems to be receiving increasing support

In his remarks President Woods pointed out the strong support given the Society by Committees C-1 and C-9, noting the impressive number of national officers that down through the years had come from these committees. A number of these men were present. The Executive Secretary in his introductory remarks commented on the important contributions many of those in the audience had made in supporting ASTM work in the technical, administrative, and meetings fields.

Throughout the week of the meeting, two of the President's associates, Professors Dolch and McLaughlin, did yoeman work on registration and insuring that adequate meeting room facilities were available. Many of the members had the privilege of inspecting Purdue's new Memorial Building with some of the finest meeting facilities anywhere. This building, dedicated in the Fall, cost upwards of ten million dollars.

Vice-President A. Allan Bates
Featured speaker at Purdue Meeting

District Meetings in February

Date	District	Speaker	Location
Feb. 25	Philadelphia	Dr. Hugh Odishaw	Franklin Institute, Phila.
Feb. 25	Southwest	Prof. K. B. Woods	Houston

Technical Committee Notes

Statistical Help Offered to ASTM Technical Committees

Subcommittee I of Committee E-11 is called its "Committee on ASTM Problems." Made up of associate members of E-11 appointed from ASTM technical committees and representatives of the E-11 main committee, Subcommittee I is chaired by the vice chairman of Committee E-11, C. A. Bicking.

Technical committee representatives transmit to Committee E-11 problems on the application of statistical methods in standardization, and relay back to the technical committees information on the activities of Committee E-11.

The subcommittee meets at least once a year, usually at the time of the Annual Meeting of the Society, but also frequently during Committee Week. Meetings are open to all interested persons in attendance at the ASTM meeting.

An area in which Subcommittee I could very well expand its usefulness to the technical committees is in the review of proposed new standards or revised standards for adequacy of statistical implications. For example, the quantitative aspects of sampling plans, if not the qualitative, physical aspects, are within the purview of Committee E-11. Also, quantitative aspects of test procedures, such as their precision and accuracy, are proper subjects for scrutiny and constructive criticism by the committee.

In the past, many technical committees have sought the assistance of Committee E-11 in the early stages of preparation of the statistical sections of standards. Although there is no formal requirement for review prior to publication, an increased use of Subcommittee I for this purpose is desirable for several reasons. With more and more committees becoming aware of the importance of the statistical aspects of standards, the need for some common policy in their treatment becomes more necessary. Also, statistics, like any specialized area of technology, requires a very high degree of sophistication in the discipline applied, particularly when rules having wide applicability throughout the field of testing are concerned. For example, nonchemists are not likely to contribute much to the chemical aspects of a test. Similarly, nonstatisticians or slightly trained statisticians cannot be expected to carry a heavy responsibility for the statistical validity of sampling plans or techniques for expressing precision.

The area of statistics is one in which almost any technically trained person feels he has a right to dabble. Although, by and large, we trust technical people to be adequately trained in mathematics, this is not true of mathematical statistics. By and large, even present curricula of technical institutions are not giving new engineers as adequate a background in statistics as they are in other branches of mathematics. Consequently, the subject matter of statistics is widely misunderstood and just as widely misapplied. It is a matter of misapplied haste for a technical committee to release proposed standards, even in the "for information only" stage, which mishandle statistics or direct their use into wasteful channels.

Unfortunately, the opportunities for application of a "cut and dried" formula are very few, as will be found true, if one stops to think about it, in any field of science. The attempt to legislate specific rules of action in areas where the latitude for decision is very broad, as in the identification of properties of materials, can lead only to frustration. Therefore, the statistical rules must be broad ones, for example, the application of a whole sampling table or series of tables. The description of the general "rules of play" are not usually within the capabilities of untrained statisticians, and no committee interested in improving the statistical aspects of standards under its jurisdiction should be satisfied with anything less than the best professional advice.

Celebrate 15th Anniversary in Chicago

SAE-ASTM Technical Committee on Automotive Rubber, Subsection X-C (Gasket Materials) which met in Chicago, Ill., October 8, 1958.

L to R, *Rear Row:* Toman—Victor, Anderson—Goodrich, Aravosis—Allis Chalmers, D'Olier—Raybestos, Nordman—Firestone, Berry—Rogers, Lippert—Mitchell & Smith, Bukzin—U. S. Navy, Luebeck—Felt Products, Messenger—Garlock, Matelski—Wolverine, Saunders—U. S. Ordnance. *Middle Row:* Hiscott—Keasbey Mattison, Redman—Rochester Products, Stickel—Texon, Nelson—Electromotive, Hawkes—Mitchell & Smith, Fels—Armstrong, Gavan—Armstrong, Malcomson—DuPont, Crampton—Felt Products, Wager—Mundet. *Front Row:* Crystal—Caterpillar, Secy. Ponsetto—AC Spark Plug, Francis—Ford, Chairman Kapps—Farnam, Potepan—Green-Tweed, Ramage—Latex Fibers, Gordon—Vellumoid.

This is the committee that developed and is responsible for ASTM Method D 1147, Method of Test for Compressibility and Recovery of Gasket Materials, and ASTM D 1170 (SAE 90R), Spec. for Non-Metallic Gasket Materials for General Automotive and Aeronautical Purposes. After issuance, a critical examination of D 1170 by the committee and discussion with other users revealed the need for many desirable improvements. In order to produce a more usable and acceptable tool for industry, the committee recently completed a general revision of D 1170 (SAE 90R). As a result of excellent cooperation from the military, the major areas of MIL-G-12803A are a near duplicate of D 1170.

Organized in 1943, the committee, three of whose present members have served for over fourteen years, celebrated its 15th anniversary at the meeting in Chicago.

Technical Committee Notes

Sources of such advice are by no means limited to Committee E-11. However, here is a specialized group within the Society framework, vitally interested in its activities, aware of the seriousness of the problems involved by long exposure to them in ASTM, and available for advice and practical assistance.

C. A. Bicking

Cement

CRL Inspection, Standards Progress Reported

At the meeting of Committee C-1 on Cement on December 1 and 2, the Cement Reference Laboratory reported that a 12th Inspection Tour was well advanced and that the problems involved in the expansion of inspection service to include concrete inspection service were being resolved. The chemical analysis subcommittee is actively reviewing ASTM and Federal methods for the purpose of resolving differences. A review of data from a round-robin test program on portland blast-furnace slag cement has indicated the acceptability of the heat of hydration test method (C 186) for use with portland blast-furnace cement. The results indicate, however, a need for improving the reproducibility of results.

Clarification of the concept of workability of cement pastes and mortars has been studied with a report expected at the June meeting. In connection with the fineness of cement, a survey of the industry is being conducted to obtain information on bleeding rates and capacities compared to fineness. Good correlation is indicated for data from the cooperative test series for comparison of strengths between 2-in. cubes and 40-mm prisms.

The mechanical mixing of cement paste has been the subject of a cooperative investigation by 17 laboratories using ten different cements, most of which are air entraining and non-air entraining types. This program was conducted using a mechanical mixing method developed at the National Bureau of Standards in comparison with ASTM methods using hand mixing. The results indicate the two methods are comparable, either method being satisfactory. A slight reduction in water requirements for normal consistency was found with the use of the mechanical mixing procedure. A cooperative test program on optimum SO_3 content based on volume change of mortar specimens is planned.

A low-alkali requirement to be included as a note in the specifications for portland cement (C 150 and C 175) was critically reviewed in the light of negative votes received in a recent committee letter ballot. The specification for masonry cement (C 91) will be revised as the result of action taken by the committee which will improve the understanding and intent of the specification in respect to the proportion of masonry cement and blended sand. This will bring it more in line with the Federal specification. A staining test on masonry cement will be considered, as well as the determination of soluble alkali by means of flame photometry. Twelve laboratories are participating in a joint program with Committee C-12 on the effect of time of setting as affecting the water retention of masonry mortar.

X-Ray Powder Data Program Expanded

Books to Supplement Data Cards

It is most interesting to note that in the tenth year of its existence, the X-Ray Associateship at the Bureau of Standards will now be expanded by increasing the available funds to provide for three full-time assistants. In 1949 the X-Ray Associateship was established on a temporary basis by the Joint Committee on Chemical Analysis by Powder Diffraction Methods to provide for one technician for one year. The first job of the associateship was to review existing data in the card file and to eliminate cases of several diffraction patterns for the same material either by agreeing that one of the existing data cards was correct or by obtaining a suitable sample of the material and substituting the correct data. Since that time the project has indexed many of the existing patterns, and has supplied data on a number of new materials.

At its meeting on November 7 in Pittsburgh the committee also recommended to the editor and the three associate editors of the card file that full use be made of graduate students in their schools to develop new data for the file. Such work would be paid for from joint committee funds.

Another development of great interest to people using X-ray powder diffraction data is the decision to stop printing the data in sets 1 to 5 on the 3 by 5-in. cards and to issue two books, one covering the data for organic materials and the other, data for inorganic materials. The Keysort and IBM cards will be continued. The editors are convinced that the data in sets 1 to 5 are now in very stable form and that after giving these data a final careful editorial review, publication in book form is feasible. Prices of such books will be much lower than the present prices of the card file. Similar books are planned for publication when the data in subsequent sets of the card file become stabilized.

Concrete

New Project on Radiation Shielding

Concrete for radiation shielding in nuclear installations will receive full consideration of a new subcommittee

Organizing Committee for Committee E-15 on Analysis and Testing of Industrial Chemicals, which met at ASTM Headquarters on Oct. 1, 1958

Shown left to right are R. E. Hess, ASTM Technical Secretary; R. J. Sobatzki, Rohm & Haas Co.; A. O. Bradley, du Pont Co.; S. S. Kurtz, Jr., Sun Oil Co.; Frank Y. Speight, ASTM Staff; W. O. Kirklin (chairman), Hercules Powder Co.; R. C. Johnson, Manufacturing Chemists' Assn.; J. W. Stillman, du Pont Co. (retired), former chairman, Committee E-3 on Chemical Analysis of Metals; A. B. Steele, Carbide & Carbon Chemicals Co.; A. C. Webber, du Pont Co., chairman, Committee E-1 on Methods of Testing; and W. E. Sisco, American Cyanamid Co. Messrs. Johnson, Stillman, and Webber were present by invitation because of their interests in closely related activities. H. V. Moss, Monsanto Chemical Co., member of the committee, was unable to be present.

Plans are to formally organize the new committee at a meeting to be held on Thursday, February 19, at ASTM Headquarters. While attendance will be by invitation, it is hoped that all who are interested in participating will notify Headquarters so that an invitation may be sent.

authorized at the meeting of Committee C-9 on Concrete and Concrete Aggregates held at Purdue University, December 3 to 5. The new subcommittee will be under the chairmanship of Prof. Milos Polivka, University of California.

The use of epoxy resins and related materials with concrete has led to the formation of a study group to present recommendations to the committee on the need for standards for these types of materials.

The effectiveness of mineral admixtures in preventing excessive expansion caused by alkali-aggregate reaction can be determined by a new method of test approved by the committee. The method may be used as a preliminary or screening test for determining the relative effectiveness of a number of different admixtures. Test methods for static modulus of elasticity and for creep in compression have progressed to the final draft stage. Progress was reported on two projects on pore structure covering air content and surface area and the relationship of pore characteristics, particularly in freezing and thawing.

The use of vibrated concrete may lead to new techniques in handling and molding concrete specimens as now outlined in ASTM Method C 31. Drafts of procedures are being considered. A complete report of data on the l/d ratio for concrete test cylinders is expected at the next meeting of the committee with information on molded and sawed specimens and lightweight aggregate concrete specimens. A number of proposed revisions of the standard methods for preparing and testing concrete cylinders and beams for compressive and flexural strength will lead to further clarification of the procedures.

The Los Angeles abrasion test procedure is being used to evaluate the effect of different machines on abrasion loss by using duplicate sets of samples. A proposed method of test of voids in stone-sand fine aggregate is now being reviewed. This method is being designed to determine the angularity of particles.

The cement content of fresh concrete as determined by the Willis-Hime procedure received considerable attention and discussion but there was no agreement as to just how this method can be used. The method will be published as information in the ASTM BULLETIN.

The absorption requirements for

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lightweight aggregate as specified in C 330 T were felt to be unnecessary, and action was taken to delete such requirements from the specification. Tests on underburned lumps in lightweight aggregate are under development, together with a review of gradation and uniformity of lightweight aggregate as now specified.

Definitions of initial and final setting times were approved in subcommittee and will be circulated to Committee C-9. These definitions will then be incorporated in a revision of the Proctor needle penetration method for rate of hardening of mortars (C 403 T).

The committee, together with Committee C-1, participated in a luncheon sponsored by the Chicago District. Talks by Prof. Reinhart Schuhmann, Purdue University, and ASTM Vice-President A. Allan Bates featured the luncheon program attended by a number of industry representatives as well as faculty members of Purdue University.

ACR Notes — *Research Comes First*

By R. C. ALDEN[1]

The adjective "explosive" is applied frequently to such basic factors of the modern era as population growth, cold war, and technology. And, indeed, the adjective is well deserved. All aspects of civilization are confronted with entirely new problems because of the unprecedented and largely unexpected rapid growth of populations, of military techniques, of knowledge. In the period ahead history cannot repeat itself because history provides no precedent for our present situation. Perhaps it is only in the realm of the spiritual aspects that we can find guidance for future courses of action.

In any event, ASTM is caught up willy-nilly in this maelstrom of change. Along with the rest of the world, our Society is at a crossroads. Either we adapt ourselves to the new order or we lapse into desuetude.

Consciously and subconsciously the administrative, executive, and working elements of the Society are keenly aware of these serious problems. On every hand we see evidences of active consideration and progress. Indeed, it is a high tribute to ASTM that so many responsible leaders in industry, education, and government, already busy with their own "explosive" problems, will contribute their imagination and initiative to the Society's future planning.

In addition to the numerous other factors involved, many believe it is important to establish a better understanding of the role that research plays in the standards developed by the Society. It is felt that such a better understanding will increase the professional stature of the Society and thus make it more attractive as an arena for the earlier consideration of the numerous new materials and of the many new properties of materials.

Behind nearly every ASTM standard there is a tremendous reservoir of research and development, related often to raw materials, manufacture, and utilization. That the final appraisal of the standard frequently is a rather humdrum series of round-robin tests has a tendency to obscure the real research origins of the standard.

In the field of petroleum, with which the writer is most familiar, many ASTM standards can be recalled—for example, octane number, viscosity index, vapor pressure—where Committee D-2 on Petroleum Products had the benefit of very extensive research programs from many organizations in establishing the test methods. Through the years and today these important test methods are being revised frequently to accord with new research findings.

In a working organization like ASTM, the administrative and executive echelons can only indicate desired courses of action. The action itself must arise in the working groups—in the technical committees. Thus, ACR urges the technical committees to include in their future plans a more deliberate program for publications relating to the research backgrounds of current ASTM standardization activities.

The details of a series of round-robin tests relating to an ASTM standard may be a very trivial technical or scientific contribution. On the other hand, the reasons why the series of tests were conducted are often of outstanding significance. Properly treated, such discussions can be extremely useful additions to the technical literature. And their is a large body of ASTM opinion that such publications are an essential part of the Society's adaptation to the new order.

[1] Phillips Petroleum Co. (Retired), Bartlesville, Okla.

Recent Survey of Current Activities on Fatigue

A Report of Subcommittee III on Survey of ASTM Committee E-9 on Fatigue

PREPARED BY HORACE J. GROVER[1]

SOME YEARS AGO ASTM Committee E-9 on Fatigue published the results of surveys of available fatigue testing facilities and projects[2] under way. In May, 1957 a Survey Subcommittee III sent out a questionnaire concerning recent activities in the field of fatigue. Copies were sent to approximately 180 universities, research institutes, government laboratories, and industrial laboratories known to be interested in the field. About 93 replies were received during the ensuing 11 months.

About 50 laboratories reported some 161 programs under way. The titles of these projects are listed in the following tabulation, arranged according to the laboratory in which the work was done. The subcommittee has exercised some freedom in rephrasing some titles to afford as descriptive phrasing as is compatible with reasonable brevity.

The questionnaire also asked about projects planned for the immediate future. About 41 were listed; these are included in the second tabulation following.

Suggestions for needed research in fatigue were also requested. The scattered replies to this question have been turned over to Subcommittee I on Research for their analysis and consideration.

There was also a question asked concerning facilities available for conducting commercial testing. Answers to this question were so few and generally unenthusiastic that they have not been included in this report.

APPENDIX A

CURRENT PROJECTS ON FATIGUE

1. *Allegheny-Ludlum Steel Corp.:*
   - (*a*) Axial-loading fatigue study of Alloy A-286 at 1200 F.
   - (*b*) Rotating-bending fatigue study of Alloy AF-71 at room temperature.
2. *American Steel Foundries:*
   - (*a*) Determination of rotating-bending endurance limit of Wearpact (low-alloy steel at high hardness).
3. *ARMCO Steel Corp.:*
   - (*a*) Corrosion-fatigue tests of 17-7 PH and of 17-7 type 301 sheets.
   - (*b*) Fatigue tests (as pin-ended columns) of 0.015-in. full-hard stainless steel sheet specimens.
   - (*c*) Fatigue tests of beam sections of 17-7 PH stainless steel sheet.
   - (*d*) Flexural-fatigue tests of 17-7 PH and of 17-7 type 301 sheet.
   - (*e*) Repeated compression-fatigue tests on helical springs of 17-7 PH.
   - (*f*) Resonant-fatigue tests of forged plates of SAE 1048 steel with various surfaces.
   - (*g*) Resonant-fatigue tests of hot-rolled plate specimens of SAE 1045 steel.
   - (*h*) Resonant-fatigue tests on shot-peened and unpeened sections of railroad wheels.
   - (*i*) Rotating-bending fatigue tests of ARMCO 22-4-9 stainless steel at temperatures from 200 to 1400 F.
4. *Armour Research Foundation:*

   For Curtiss-Wright Corp., Wright Aeronautical Division:
   - (*a*) Elevated-temperature tensile-fatigue tests.
   - (*b*) Tensile-fatigue properties of turbine blade alloys.

   For Wright Air Development Center:
   - (*c*) Fatigue strength of metals subjected to triaxial stresses.
   - (*d*) Fatigue studies of SAE 4340-4350 steel at 270 to 310 ksi tensile strength levels.
5. *Battelle Memorial Institute:*

   For ASTM-ASME Joint High-Temperature Panel:
   - (*a*) Factors influencing the notch fatigue strength of N-155 alloy at elevated temperatures.

   For General Electric Co. and others:
   - (*b*) Dynamic creep behavior of super-alloys.

   For Goodyear Aircraft and Air Material Command:
   - (*c*) Fatigue studies of spotwelded and riveted joints and assemblies.

   For National Advisory Committee for Aeronautics:
   - (*d*) Experimental investigation of notch-size effects on rotating-beam behavior of 7075-T6 aluminum.
   - (*e*) Fatigue behavior of aircraft structural beams.
   - (*f*) Fatigue-crack propagation in severely notched bars.

   For the Norton Co.:
   - (*g*) Effect of grinding variables on residual stresses and fatigue strength of a hardened steel.

   For Wright Air Development Center:
   - (*h*) Effects of elevated temperature on the fatigue strength of sintered aluminum powder.
   - (*i*) A system for automatic processing of fatigue data.
6. *Bell Telephone Laboratories, Inc.:*
   - (*a*) A planned statistical study of fatigue.
7. *Boeing Airplane Co.:*
   - (*a*) Fatigue tests of 6Al-4V titanium-alloy extrusion.
   - (*b*) Fatigue tests of 7079-T6 and 2014-T6 aluminum-alloy sheet.
   - (*c*) Fatigue tests of aluminum and of magnesium-alloy castings.
   - (*d*) Fatigue tests of cold-worked 2024-T aluminum-alloy sheet.
   - (*e*) Fatigue tests of milled *versus* milled-plus-shotpeened 7178-T6 aluminum-alloy plate.
   - (*f*) Study of fretting.
8. *Brown University:*

   For Office of Ordnance Research, Department of Army:
   - (*a*) Basic research on fatigue failures under combined stress.
9. *Canadian Bureau of Mines:*
   - (*a*) Fatigue-damage study.
   - (*b*) Stress history.
10. *Case Institute:*

    For Steel Founders' Society of America:

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[1] Battelle Memorial Institute, Columbus, Ohio; Chairman of Subcommittee III in 1958.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 50, p. 499 (1950), and Vol. 52, p. 606 (1952).

(*a*) Study of the comparative engineering characteristics of steel castings and equivalent weldments.

11. *Columbia University:*
For Wright Air Development Center:
(*a*) Fatigue under random loadings.

12. *Curtiss-Wright Corp., Propeller Division:*
(*a*) Fatigue studies of aluminum alloys.
(*b*) Fatigue studies of high-strength bronze materials.
(*c*) Fatigue studies of high-strength steels.
(*d*) Fatigue studies of welding fluxes.
For Wright Air Development Center, Materials Laboratory:
(*e*) Investigation of materials-fatigue problems.
For Wright Air Development Center, Propeller Laboratory:
(*f*) Effect of surface treatment of aluminum and titanium on fatigue strength.

13. *Curtiss-Wright Corp., Wright Aero Division:*
(*a*) The effect of a composite Woods-nickel and Watts-nickel strike on the fatigue strength of AMS-5613.
(*b*) Fatigue properties of air-melted and vacuum-melted WAD-8105.
(*c*) Fatigue properties of cast aluminum alloys, RR-250 and RR-350.
(*d*) Fatigue properties of cast N-155.
(*e*) Fatigue properties of Republic Steel alloy, RS-130-B.
(*f*) Fatigue properties of vacuum and argon cast Inconel-713.
(*g*) Fatigue properties of vacuum cast Udimet-600.

14. *Douglas Aircraft Co., Inc.:*
(*a*) Effects of zinc-sprayed finish and sandblast numbering on the fatigue life of 7075-T6 extrusion.
(*b*) Fatigue and static strengths of mollerized SAE 4130 steel.
(*c*) Hydraulic-pulsing fatigue test of 356-T6 and A356-T61 aluminum casting alloys.
(*d*) Fatigue strength of shot-peened 7075-T6 aluminum alloy.
(*e*) Surface finish *versus* fatigue life of 2014-T6 aluminum and O-HTA magnesium.
(*f*) Fatigue tests of anodized aluminum: water-sealed *versus* steam-sealed.
(*g*) Improving the fatigue life of chromium-plated steel by shot-peening.
(*h*) Shotpeened 7075-T6 fatigue strength.
For U. S. Air Force, Air Material Command:
(*i*) Improving fatigue life of formed stainless steel hydraulic tubing by prestressing.
(*j*) Fatigue strength of hydraulic tubing.

15. *E. I. du Pont de Nemours and Co., Inc., Engineering Research Laboratory:*
(*a*) Effect of second phase ferrite stringers on fatigue properties of stainless steel.

16. *Ecole Polytechnique:*
For Pressure Vessel Research Committee:
(*a*) Plastic fatigue tests of model pressure vessels.
For Welding Research Council of the American Welding Society:
(*b*) Room-temperature fatigue resistance of pressure vessels.
(*c*) High-temperature creep resistance of pressure vessels.
(*d*) Hydrostatic compression for improving the fatigue resistance of spot welds.

17. *Fafnir Bearing Co., Inc.:*
(*a*) Rolling contact fatigue.

18. *General Electric Co.:*
(*a*) Effect of several surface finishes on the endurance limit of titanium.
(*b*) Influence of cold working on the fatigue strength of copper.

19. *Goodyear Aircraft Corp.:*
For Wright Air Development Center:
(*a*) Helicopter blade structural material.
For Wright-Patterson Air Force Base, Air Material Command:
(*a*) Development program for resistance spot welding and seam welding of aluminum alloys.

20. *Illinois, University of:*
For American Railway Engineering Assn. and American Iron and Steel Inst.:
(*a*) Investigation of fatigue failures in railroad rails.
For National Advisory Committee for Aeronautics:
(*b*) Fatigue damage during complex stress histories.
For Wright Air Development Center:
(*c*) Fatigue behavior of alloys of molybdenum diluted with carbon and nitrogen.
For General Electric Co.:
(*d*) Durability of mean stress under conditions of constant mean and applied strain.
For U. S. Naval Bureau of Ordnance:
(*e*) Investigation of fatigue characteristics of leaded SAE 4340 steel.

20*a*. *Illinois, University of, Civil Engineering Department:*
(*a*) Welded connection in reinforcing bars tested at variable stress cycles in axial-loading fatigue at room temperature.
For Association of American Railroads, Bureau of Public Roads:
(*b*) Flexural-fatigue strength of welded beams and girders.
For Illinois Division of Highways, Research Council on Riveted and Bolted Structural Joints:
(*c*) Cumulative-fatigue damage in structural joints.
(*d*) Effect of bearing pressure on the fatigue strength of riveted joints.
(*e*) Effects of repeated loadings on structural connections with high-strength bolts.
(*f*) Static and fatigue tests of structural joints with over-stressed high-tensile steel bolts.
(*g*) Static and fatigue tests of rivets and high-strength bolts in direct tension.
For Welding Research Council, AISI Engineering Foundation:
(*h*) Axial-fatigue evaluation of small, round, notched specimens of alloy steels at room temperature.
For Welding Research Council:
(*i*) Theoretical analysis of existing data on fatigue.

20b. *Illinois, University of, Theoretical and Applied Mechanics Department:*
For U. S. Navy, Bureau of Ships:
(*a*) Repeated-load studies of welded and clad plate.

21. *Iowa State College:*
For Institute of Atomic Research:
(*a*) Fatigue testing uranium at elevated temperatures.

22. *Lehigh University:*
For KSM Products, Inc.:
(*a*) Fatigue-strength study of stud shear connectors for composite beam bridges.
For University Research Committee, Welding Research Council.
(*b*) Accelerated fatigue testing (Prot method) of welded joints.

23. *Lessells and Associates, Inc.:*
(*a*) Corrosion fatigue of aluminum alloy.
For ALCO Products, Inc.:
(*b*) Fatigue of large diesel crankshafts.
(*c*) Surface fatigue of leaded steels.
For Wright Air Development Center, Materials Laboratory:
(*d*) Axial-fatigue tests of high-strength steels.
For Wright Air Development Center, Propeller Laboratory:
(*e*) Protective shotpeening of propeller blades.
For Raytheon Manufacturing Co.:
(*f*) Surface fatigue of non-ferrous materials.

24. *Link-Belt Co.*
(*a*) Fatigue life of roller chain and silent chain.

25. *Lockheed Aircraft Corp.:*
(*a*) Spectrum loading study.

26. *Martin Co., The:*
(*a*) Fatigue testing of new metals and alloys.
For Wright Air Development Center, Materials Laboratory:
(*b*) Development of sandwich construction material for high-temperature application.

27. *Massachusetts Institute of Technology:*
For Wright Air Development Center:
(*a*) Relationship between fatigue and metallurgical structures.

28. *Menasco Manufacturing Co.:*
(*a*) Fatigue strength of steel tubes.

29. *Minnesota, University of, Department of Mechanics and Materials:*
For Wright Air Development Center, Materials Laboratory:
(*a*) Study of high-stress damping and the mechanism of fatigue in high-purity aluminum.
(*b*) Axial-stress fatigue, creep, and rupture properties of unnotched and notched specimens of new heat-resistant alloys.
(*c*) Basic study of sonic fatigue.
(*d*) Effect of an increasing cyclic modulus on bending-fatigue strength of aluminum.
(*e*) Effect of nonlinear stress-strain properties under fatigue on stress distribution with particular reference to notched specimens.
(*f*) Effect of static prestrain on Prot fatigue properties of unnotched materials at room temperature and at elevated temperatures.
(*g*) Grain-size effect on fatigue and creep, and their relationship to notch geometry, stress gradients, and specimen size.

30. *NACA-Langley Aeronautical Laboratory:*
(*a*) Crack initiation in lithium fluoride.
(*b*) Crack propagation in aluminum-alloy sheet specimens.
(*c*) Cumulative damage in structural aluminum alloys.
(*d*) Effects of atmospheric corrosion on fatigue behavior of aircraft structural aluminum alloys.

31. *NACA-Lewis Flight-Propulsion Laboratory:*
(*a*) Effects of solution treatment and grain size on the elevated-temperature fatigue strength of Inco-700 alloy.
(*b*) Investigation of elevated-temperature, combined stress-rupture and fatigue strength of Waspalloy having different aging treatments and molybdenum contents.

32. *National Bureau of Standards:*
For U. S. Navy, Bureau of Aeronautics:
(*a*) The effect of load level and cyclic history on cumulative-damage ratio of structural elements subjected to repeated loads.

33. *New York Naval Shipyard, Materials Laboratory:*
(*a*) Investigation of fatigue properties of full-scale crankshafts.
(*b*) Large-scale fatigue tests of joints in reinforced plastics.

34. *North American Aviation, Inc., Missile Development Division:*
(*a*) Comparative Mechanical and endurance (under bending and under tension-tension) of Chem-milled, machine-milled, and parent steel alloys and titanium alloys.

35. *Ontario Research Foundation:*
(*a*) The progress of fatigue (damage), followed by magnetic and ultrasonic testing methods.

36. *Ohio State University:*
For Wright Air Development Center:
(*a*) Cumulative fatigue damage.
(*b*) Effects of complex stress-time patterns on the endurance properties of metals.
(*c*) Fretting fatigue of titanium steel joints.

37. *Reynolds Metals Co., Metallurgical Research Laboratories:*
(*a*) Experimental evaluation of bending and of axial-loading fatigue properties of aluminum alloys.

38. *Republic Steel Corp., Titanium Research Laboratory:*
(*a*) Fatigue data usually incorporated in laboratory reports dealing with endurance-limit fatigue determinations on notched and unnotched specimens representative of specific steels, titanium alloys, and heat treatments.

39. *Syracuse University, Research Institute:*
For Kelsey-Hayes Wheel Co.:
(*a*) Development of processes which will result in the maximum service life of light-alloy wheels.
For National Advisory Committee for Aeronautics:
(*b*) Tension-compression fatigue tests of several alloys to determine their suitability as bearing materials.
For Watertown Arsenal:
(*c*) Relation between direct-stress and bending fatigue of high-strength (200–270 ksi) steel (SAE 4340) without or with hydrogen embrittlement.
For Wright Air Development Center:
(*d*) Design properties of high-strength steels in the presence of stress concentrations and hydrogen embrittlement.
(*e*) Effects of hydrogen embrittlement on rotating-bending fatigue properties of high-strength steels.

40. *United Aircraft Corp., Hamilton Standard Division:*
(*a*) Effect of hardness on the fatigue strength of notched SAE 4340 steel tested with mean stress.

41. *U. S. Army Ordnance Corps, Rock Island Arsenal:*
(*a*) Effect of preset strain and of hardness on fatigue life of torsion bar springs.

42. *U. S. Department of Agriculture, Forest Products Laboratory:*
For Association of American Railroads:
(*a*) Fatigue resistance of one-quarter-scale railroad bridge stringers.
For Wright Air Development Center, Materials Laboratory:
(*b*) Fatigue properties of reinforced plastic laminates under axial stress.

43. *U. S. Naval Air Development Center:*
For U. S. Navy, Bureau of Aeronautics:
(*a*) Development of bomb suspension hook materials for bomb shackles and racks.
(*b*) Endurance tests of aluminum and of magnesium alloys containing various degrees of dispersed discontinuities.

44. *U. S. Naval Air Material Center:*
For U. S. Navy, Bureau of Aeronautics:
(*a*) An attempt to improve the elevated-temperature fatigue properties of S-816 alloy by surface treatment.
(*b*) Development of information concerning the fatigue characteristics of full-scale aircraft.
(*c*) Development of information concerning the fatigue characteristics of full-scale aircraft structures.
(*d*) Direct-stress endurance tests of magnesium-casting alloys containing various degrees of dispersed discontinuities.
(*e*) Effect of hard anodic coating on the flexural-fatigue properties of aluminum alloys.
(*f*) Effect of anodic coating on the flexural-fatigue properties of magnesium.
(*g*) Effect of coatings other than chemical and electrodeposits on the rotating-bending fatigue properties of high-strength steels.
(*h*) Effect of load level and cyclic history on cumulative-damage ratio of structural elements subjected to repeated loads.
(*i*) Effect of plating on rotating-bending and flexural-fatigue behavior of high-strength steels.
(*j*) Effect of shotpeening on fatigue properties of 7075 aluminum alloy.
(*k*) Effect of vibratory stresses during aging on elevated-temperature fatigue life.
(*l*) Elevated-temperature flexural-fatigue tests of brazed S-816 alloy.
(*m*) Evaluation of the rotating-bending fatigue properties of 7079 aluminum-alloy hand forgings.
(*n*) Fatigue evaluation of blind structural 56-S aluminum-alloy rivets.
(*o*) Rotating-bending and axial-loading fatigue evaluation of properties throughout a large X7079 aluminum plate.
(*p*) Rotating-bending and direct repeated-stress evaluation of cold-drawn steel at high-strength levels.
(*q*) Rotating-bending fatigue evaluation of brush-plating process.
(*r*) Rotating-bending fatigue evaluation of coating deposited from chromium-plating bath containing special additive.
(*s*) Repeated-bending fatigue eval-

uation of Rem-Cru Titanium alloy B-120-VCA.

(*t*) Rotating-bending fatigue evaluation of Thermenol at room temperature and at elevated temperatures.

(*u*) Rotating-bending fatigue evaluation of XA-140-F aluminum alloy at room temperature and at elevated temperatures.

45. *U. S. Naval Ordnance Laboratory:*
For U. S. Navy Department, Bureau of Aeronautics:
(*a*) Endurance tests of aluminum and of magnesium alloys containing various degrees of dispersed discontinuities.

46. *U. S. Naval Research Laboratory, Metallurgy Division:*
(*a*) Effect of environment on fatigue.

47. *U. S. Steel Corp., American Steel and Wire Division:*
(*a*) Rotating-strut test of valve-spring wire.
For National Standard Co.:
(*b*) Rotating-strut tests of copper ply wires.
For Reynolds Metals Co.:
(*c*) Rotating-strut tests of several lots of aluminum wire.

APPENDIX B

FATIGUE PROJECTS PLANNED FOR IMMEDIATE FUTURE

1. *American Steel Foundries:*
(*a*) Comparison of Wearpact steel with higher carbon content and higher tensile strength.
(*b*) Comparison of Wearpact steel with normal and modified grade B steels.
(*c*) Effects of rare earth elements on cast and forged steels.

2. *American Welding Society, Pressure Vessel Research Committee:*
(*a*) Plastic fatigue tests of pressure vessels.

3. *Boeing Airplane Co.:*
(*a*) Effect of decarburizing on rotating-bending fatigue strength of SAE 4340 and 4330 steels heat treated to various strength levels. The effect of shotpeening the as-heat-treated surface may also be investigated.
(*b*) Rotating-bending fatigue tests of Consutcode SAE 4340 steel to determine whether this type of melting has any advantage fatiguewise over air-melted SAE 4340 steel.

4. *Curtiss-Wright Corp.:*
(*a*) Detection of early fatigue damage.
(*b*) Effect of case removal on the fatigue properties of AMS-6260 and AMS-6270.
(*c*) Effect of forging and bar stock flow lines on the fatigue strength of AMS-6260.
(*d*) Endurance testing of precision-forged titanium compressor rotor blades.
(*e*) Evaluation of shotpeening on the endurance strength of carburized AMS-6260.
(*f*) Resonant fatigue testing of turbine-blade alloys.
(*g*) Thermal fatigue evaluation of Battellalloy.

5. *Curtiss-Wright Corp., Propeller Division:*
(*a*) Fatigue tests on cast aluminum.
(*b*) Vacuum-melted SAE 4340 made by special vacuum-melting process. Work will probably be done in conjunction with Utica Drop Forge Co. and/or Armour Research Institute.

6. *Curtiss-Wright Corp., Wright Aeronautical Division:*
(*a*) Endurance testing of precision-forged titanium compressor rotor blades.

7. *General Electric Co.:*
(*a*) Fatigue strength of brazed titanium joints.

8. *Goodyear Aircraft Corp.:*
(*a*) Fatigue tests of entire inflated fabric rotor blades under simulated flight loadings.

9. *Illinois, University of:*
For McDonnell Aircraft Corp.:
(*a*) Stress-analysis study to get information on the design of lugs under fatigue loads—SAE 4340 steel and aluminum.

10. *Lessells and Associates, Inc.:*
(*a*) Crack propagation in 7-in. diameter shafts which cracked in service. Shafts to be tested in resonant bending.
(*b*) Fatigue of 9-in. bore cylinder heads using a new resonant hydraulic machine developed for the purpose.
(*c*) Surface fatigue of non-ferrous materials with various surface treatments.

11. *Link-Belt Co.:*
(*a*) Experimenting with different ways of making the chain fatigue-resistant. Both on a gross and on a more fundamental level.

12. *Martin Co., The:*
(*a*) Elevated-temperature fatigue of honeycomb-sandwich structures.

13. *Menasco Manufacturing Co.:*
(*a*) Continued evaluation of the effects of design and manufacturing variables on fatigue strength of tubes.

14. *National Advisory Committee for Aeronautics:*
(*a*) Investigate the fatigue behavior of alloys at elevated temperature under various atmospheres.

15. *Ontario Research Foundation:*
(*a*) Further studies on the effects of a strong magnetic field on the fatigue life of ferromagnetic materials and the loss of ductility in the tensile test as a criterion of fatigue damage, using electrolytic hydrogen to accentuate the ductility loss. In addition, it is intended to make a study of the breakdown of the elastic stage and of fatigue conditions, using ultrasonic investigation methods.

16. *Rem-Cru Titanium, Inc.:*
(*a*) Axial-tension fatigue studies on commercial titanium alloys, using smooth and notched specimens.

17. *Republic Steel Corp.*
(*a*) Development of endurance fatigue at various temperature levels for commercially pure and alloy titanium.
(*b*) Effect of grain size on endurance limit of alloy-steels, of titanium, and of titanium alloys.
(*c*) Notched and unnotched endurance fatigue of titanium-alloy grades, annealed and heat treated, including effect of notch radius.

18. *U. S. Department of Agriculture, Forest Products Laboratory:*
(*a*) Study of the notched effects on plastic laminates.

19. *U. S. Naval Air Development Center:*
(*a*) Measurement, analysis, and simulation of flight vibrations encountered on bomb-suspension equipment (using mounted) on various Naval aircraft to establish design and test criteria.

20. *U. S. Naval Air Material Center:*
(*a*) Fatigue investigation of wings of magnesium-aluminum construction.
(*b*) Fatigue investigation of wings of sandwich construction.
For U. S. Navy Department, Bureau of Aeronautics:
(*c*) Effect of vibratory stresses during aging on elevated-temperature fatigue life, using locally designed turbine blade tester in combined tensile and bending.
(*d*) Flexural-fatigue test of brazed S-816 alloy at elevated temperature.
(*e*) Evaluation of notched and unnotched specimens of cold-drawn SAE 4140 steel at ultra-high-strength levels tested at room temperature.
(*f*) Rotating-beam, direct, axial stress evaluation of the fatigue properties of notched and unnotched specimens of 7079 aluminum-alloy handforgings tested at room temperature. Tensile and compression properties will also be determined.
(*g*) Flexural-fatigue evaluation of notched and unnotched specimens of Rem-Cru Titanium alloy B-120-VCA tested at room temperature.

21. *U. S. Naval Ordnance Laboratory:*
(*a*) Study effect of hydrogen-gas porosity on endurance properties of aluminum alloy 356.

Random Samples...

FROM THE CURRENT MATERIALS NEWS

From the broad stream of current materials information flowing from "in-box" to "out-box" in a busy editorial office, random samples (mostly random) have been plucked. Thinking them worth re-showing to ASTM'ers who may have missed the original articles, we have included them here. Of course, we had to trim the samples to fit. There will be those who are not satisfied with samples, especially ones which are not really random. But these ASTM'ers can contact the institution, magazine, governmental agency, etc., who placed the original information in the stream, or address Random Samples, ASTM, 1916 Race St., Philadelphia 3, Pa.

Hail, Columbium!

HEREAFTER, the lustrous, steel-gray metallic element, columbium, will be called columbium; and the lustrous, steel-gray element, niobium, also will be called columbium, so far as the American Institute of Mining, Metallurgical, and Petroleum Engineers officially is concerned. For columbium and niobium are two names for the same element, and the Board of Directors of AIME, acting to dissipate long-standing confusion, has voted to call this element by the name it has had since its discovery, columbium, and not by what many metallurgists regard as a Johnny-come-lately name, niobium.

A rose by any other name.—The poet's rose may smell as sweet, but the Board's action reflects a widespread conviction among metallurgists that this poetic sentiment cannot justify the use of two names for element 41 where one will suffice. With the growing use of columbium in such high-temperature equipment as nuclear reactors and jet engines, the question of a single, universally accepted name for the metal has become of more than academic importance.

Hatchett's discovery.—As recounted in the *Journal of Metals*, published by the Metallurgical Society, discovery of columbium was announced in a paper read in 1801 before the Royal Society of London by Prof. Charles Hatchett. His review, entitled "An Analysis of a Mineral Substance from North America Containing a Metal Hitherto Unknown," described his experiments with a mineral found in Massachusetts, a sample of which had been sent by a "Mr. Winthrop" to Sir Hans Sloane, who had deposited the ore in the British Museum.

"Considering that the metal is so very different from those hitherto discovered, it appeared proper that it should be distinguished by a peculiar name," Hatchett urged the Royal Society. Being aware that the people of the United States attached derivatives of Columbus' name to many places and that this custom often applied to scientific discoveries, Hatchett continued, "Having consulted with several of the eminent and ingenious chemists of this country, I have been induced to give it the name of columbium." Thus Hatchett, following custom often practiced in the naming of scientific discoveries, used the area of origin. The ore became known as columbite.

A name by any other Rose.—The fair name of columbium was not to remain unmuddied for long. Only one year later, Ekeberg, in Sweden, discovered an element he called tantalum. It was erroneously reported to be identical with columbium, which, even that early, seemed fated to be the victim of confusion. This error fluorished for over four decades. The one H. Rose, after researches on columbite, muddied the waters further by reporting that the mineral contained what he supposed to be a new metal, which he named niobium.[1] By the time it was realized that Hatchett's columbium was not Ekeberg's tantalum, but, rather, Rose's niobium, usage had given niobium something of an advantage.

A voice in the wilderness.—In 1854, Prof. A. Connell, of London, pointed out that Rose had been in error. Connell emphasized that columbium and niobium were the same and that columbium and tantalum were not the same.

The issue was further clarified by J. Lawrence Smith, of Louisville, Ky., in 1877, in the *American Journal of Science*. Smith observed that it was "the common practice" of American chemists and mineralogists "to speak of the metal which is called niobium by English and Continental chemists, as columbium." He continued: "This is eminently just, since the metal was discovered and well defined and named columbium forty-five years before the name niobium was given to it. The change of name was caused by a double mistake in no way connected with the original observations in 1801 by Professor Hatchett.

"The result of Rose's research was, in fact, simply the demonstration of the actual difference of columbium and tantalum; for Hatchett's discovery was clear, precise, and well made out, and has never been controverted." Instead of calling columbium by the name of niobium, said Smith, "its original name should have been left to it. It is but right, just, and in accordance with chemical and mineralogical precedence that the name given by the discoverer should replace that of niobium, which originated forty-five years later."

However, at the time of the Smith article, though tantalum had been recognized as being distinct, the names columbium and niobium had grown into synonymous use. "And so the problem has come down through the years," the *Journal of Metals* has written, adding that to all commercial users of the metal, columbium is the accepted name. Columbium-stabilized stainless steel is a fully accredited standard grade and ferrocolumbium is a recognized alloy for making columbium-containing alloys. No melting metallurgist thinks of any other name. Yet, the chemists and some metallurgists still insist on niobium. In 1949, this insistence took the form of a resolution of the International Union of Pure and Applied Chemistry, adopting the name niobium; the American Chemical Society and the National Research Council concurred. No metallurgical society has approved this change.

As to why it was felt necessary for AIME to make a decision now, the *Journal of Metals* says: "At the present time, with the metal playing an increasingly important role in high-temperature metals and reactor technology, the need for a single name becomes more and more necessary.... Niobium is not the proper name for element 41. A wrong, even though far removed in time and space from its inception, remains a wrong."

[1] In Greek mythology, Niobe, daughter of Tantalus (for whom tantalum was named), was changed by Zeus into a stone, which continued to weep for the slain children of Niobe.

A Method of Test for Potential Efflorescence of Masonry Mortar

By P. L. ROGERS[1]

This method of test is intended to determine quantitatively the potential efflorescence of mortar for unit masonry by measuring the water-soluble salts picked up by a ceramic wick imbedded in the mortar under prescribed conditions. The method may be used to test mortar either as proportioned and prepared in the laboratory or as prepared for use on the job.

Three masonry cements having a wide range in water-soluble alkali content were used with Ottawa testing sand. Test results found by the seven cooperating laboratories were found to be in close agreement. However, the material extracted from the wicks did not correlate well with the amount of water-soluble alkalies found in the cements by ASTM Method C 114 – 58 T.[2] The results are apparently influenced by the total alkali and the amount of entrained air.

Subcommittee II on Research and Methods of Test of ASTM Committee C-12 on mortar is unanimous in desiring to have the results of this research work printed as information. There were strong negative opinions expressed by a minority of the members against recommending this method as a tentative standard. It was thought there might be too strong a reliance on the test method in preventing efflorescence even though it is known that the results of tests and use of materials are often contradictory. Efflorescence may be caused by water-soluble salts coming from any of the components making up the masonry or by atmospheric pollution. The occurrence of efflorescence depends on many factors other than the composition of the mortar.

This report supplements the September, 1954,[3] report of the Working Subcommittee on Efflorescence[4] of ASTM Committee C-12 on Mortar for Unit Masonry. Description of a gravimetric test method with results of the test found by the subcommittee are reported. Description of the method with a comparison of the results of the tests with those of the subcommittee using a gravimetric method are reported.

The use of descriptive terms such as little, medium, or heavy in estimating the amount of efflorescence developed in any test method has always seemed inadequate. It was recognized by Subcommittee II on Research and Methods of Test that some method of measuring the amount of efflorescence developed on any test specimen had to be devised. Previous work described in the September, 1954, report indicated that the use of a ceramic wick appeared to offer a good basis for such a method. T. Ritchie (**1**)[5] used ceramic wicks in his studies on efflorescence, and it is this method with modifications that was used by the subcommittee as a gravimetric test for potential efflorescence of masonry mortar.

Mortar Materials

Three samples of masonry cement were selected so as to represent the probable range of efflorescing tendency to be found in such materials as offered to the trade. The fine aggregate used was a blend of equal parts by weight of standard Ottawa sand and graded Ottawa sand as specified in ASTM Specifications for Masonry Cement C 91 – 57.[6]

Ceramic Wicks

Standardized wicks made from red-firing clay, termed Efflorwicks, were obtained from the Research Department of the New York State College of Ceramics, Alfred University. They were specially prepared for studying the efflorescing tendency of various masonry materials (**2**).

The wicks have one end semicircular in shape, the other end rectangular. The average dimensions of ten Efflorwicks were found to be 74 mm long, 49 mm wide, 5 mm thick, 25 mm radius of curvature of the rounded end. The average dry weight was 32.03 g. The absorption, when placed to a depth of 32 mm in water for 1 min, rounded end up, was 2.63 g.

Procedure[7]

Weighed amounts of mortar mixed according to ASTM specifications C 91 – 57, Section 20[6], were placed in paper cups. After the mortar had set, the paper was stripped away and the specimens were placed in a measured quantity of water. The specimens were snugly covered with dental rubber in such a manner that the rounded end of the the wicks protruded, and the water traveled up through the wicks to evaporate. Soluble salts accumulated at the top end of the wicks. To determine the amount of soluble material thus transmitted to the wicks, the wicks were broken off at the top of the mortar, dried, weighed, and then washed in water, dried and weighed again. The loss in weight was considered to be a measure of the soluble material picked up by the wick from the mortar in a manner similar to that occurring in masonry work.

Test Program and Results

Seven cooperating laboratories made triplicate tests on each of three mortars. The results of these tests are given in Table I as averages of the three tests run on each mortar.

TABLE I.—EFFLORESCENCE TESTS AVERAGED RESULTS, WEIGHT LOSS g.

Laboratory	Cements		
	A	*B*	*C*
1	0.0964	0.1321	0.0666
2	0.0952	0.1367	0.0614
3	0.0874	0.1384	0.0667
4	0.1113	0.1454	0.0631
5	0.1137	0.1456	0.0772
6	0.0995	0.1294	0.0691
7	0.1193	0.1493	0.0716
Mean weight loss, g	0.1033	0.1396	0.0680
Standard deviation	0.0103	0.0060	0.0043
Coefficient of variation, per cent	10.0	4.3	6.3
Standard error	0.0039	0.0023	0.0016

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Vice-president of Research, Riverton Lime and Stone Co., Riverton, Va.

[2] Methods of Chemical Analysis of Portland Cement (C 114 – 58 T), 1958 Book of ASTM Standards, Part 4.

[3] P. L. Rogers, "Developing a Test Method for Efflorescence of Masonry Mortar," ASTM BULLETIN, No. 200, Sept., 1954, p. 64 (TP 190).

[4] Members of the Working Subcommittee on Efflorescence who provided the test results were: Wayne Brownell, Paul V. Johnson, W. J. McCoy, James A. Murray, T. Ritchie, P. L. Rogers, and E. J. Wechter.

[5] The boldface numbers in parentheses refer to the list of references appended to this paper.

[6] 1958 Book of ASTM Standards, Part 4.

[7] Procedure given in detail as an appendix to this paper.

In order to gain more information on the nature of the cements used, the alkali content of the three cements was determined by two laboratories. The results of the water-soluble alkali and the acid-soluble alkali tests are reported in Tables II and III.

The material penetrating into the ceramic wick was extracted and its composition determined by one laboratory; the results are given in Table IV.

TABLE II.—COOPERATIVE TEST RESULTS ON WATER-SOLUBLE ALKALI DETERMINATIONS—ASTM METHOD C 114 – 58.[a]

THREE MASONRY CEMENTS

Cement	Per Cent Na_2O		Per Cent K_2O	
	Laboratory 2	Laboratory 7	Laboratory 2	Laboratory 7
A	0.05	0.05	0.25	0.25
B	0.09	0.09	0.38	0.38
C	0.00	0.00	0.03	0.02

[a] 1958 Book of ASTM Standards, Part 4, p. 63, Section 23.

TABLE III.—ACID-SOLUBLE ALKALI DETERMINATIONS—ASTM METHOD C 114 – 58T.[a]

RESULTS ON THREE MASONRY CEMENTS BY LABORATORY No. 2

Cement	Per Cent Na_2O	Per Cent K_2O
A	0.06	0.42
B	0.17	0.56
C	0.08	1.30

[a] 1958 Book of ASTM Standards, Part 4, p. 102, Section 18.

TABLE IV.—COMPOSITION OF EXTRACTS AS PROVIDED BY LABORATORY No. 7.

The following are averages of individual tests expressed as per cent of wick loss. The totals are less than 100 per cent because of undetermined constituents such as carbonate and water of hydration.

Composition of Water Extract, per cent of Wick Loss.

	Cement A	Cement B	Cement C
Na_2O	14.0	14.7	8.7
K_2O	41.5	40.7	39.4
CaO	0.0	0.0	0.0
SO_3	4.5	6.2	4.3

Composition of Acid Extract, per cent of Wick Loss.

	Cement A	Cement B	Cement C
Na_2O	2.0	3.8	2.0
K_2O	3.2	5.7	4.5
CaO	50.5	42.9	48.2

Discussion

The most interesting feature of these tests is the relation between efflorescence of the mortars as found by this method and the soluble alkali content of the cements used. This, however, cannot be a rigorous relationship if under the job conditions sand and water may contribute soluble material that would appear as efflorescence. In these tests care was taken to be sure that the sand and water would not contribute toward efflorescence. The cements were selected to have a wide range of soluble alkali that might provide efflorescence. The tests indicate a good degree of reliability and agreement among laboratories for each of the cements in the amount of material extracted from the wicks. However, the amount extracted from the wicks is not proportional to the alkali content of the cements and it appears that there are at least two reasons for this.

Cement C is nonstaining and without intentionally entrained air. The water-soluble alkali content according to Method C 114–58 T[2] is quite low. However, the acid-soluble alkali is high. Under longer exposure to a wet condition this mortar may liberate more alkali than would be found by the test method for water soluble alkali. Furthermore, this mortar because of its low air entrainment would be more susceptible to extraction than one with the usual amount of entrained air.

The amount of water-soluble material extracted from the wicks was not always proportional to the appearance of efflorescence on the wicks. This is supported by studies of B. Butterworth (**3**) which show that the soluble materials do not always deposit uniformly on the face of brick or porous units. Surface deposition depends on the pore structure and rate of evaporation. In any form of wick test, a portion of the soluble material remains back of the surface. Likewise in a masonry wall a major part of the water soluble material remains behind the surface for some time and may never actually reach the surface, or it may migrate back and forth with much of it eventually coming to the surface and washing away.

Subcommittee II of ASTM Committee C-12 is unanimous in desiring to have the results of this research work printed as information only. It was the opinion of some of the members of the committee that this method had not reached a degree of quality to be presented to the Society for publication as tentative standard. It was thought that there might be too strong a reliance on the test method for preventing efflorescence when it is known that the results of tests and use of materials are often contradictory. The occurrence of efflorescence depends on many factors other than the composition of the mortar. The difficulties in understanding the problems of efflorescence are well discussed by B. Butterworth (**4**).

REFERENCES

(**1**) T. Ritchie, "Study of Efflorescence Produced on Ceramic Wicks by Masonry Mortars," *Journal*, Am. Ceramic Soc., Vol. 38 (10), pp. 362–366 (1955).

(**2**) C. R. Amberg and L. Washburn, "Wick for Testing Efflorescence Tendencies of Materials," *Bulletin*, Am. Ceramic Soc., Vol. 25 (1), pp. 7–9 (1946).

(**3**) B. Butterworth, "Contributions to the Study of Efflorescence, Part VIII.—The Cameraman Theory," *Transactions*, British Ceramic Soc., Vol. 53 (9), pp. 596–597 (1954).

(**4**) B. Butterworth, "Efflorescence and Staining of Brickwork," *The Brick Bulletin*, Vol. 3 (5), pp. 8–9 (1958).

APPENDIX

PROPOSED METHOD OF TEST FOR POTENTIAL EFFLORESCENCE OF MASONRY MORTAR

Description:

Procedure.—The ceramic wicks are prepared for use prior to mixing the mortar, keeping in mind that the tests are made in triplicate. A blank determination shall be run in triplicate in the same manner as the other tests except that no mortar is used. It is essential to form a line of weakness across one side of the wick parallel to the bottom and 32 mm from the bottom. This line is a scratch approximately 1 mm deep formed by either a small triangular file or a hacksaw blade. It has been found best to use a hacksaw to start the scratch and then use a file to finish and make the scratch more uniform. Care must be taken to keep the wicks clean at all times when handling is necessary.

Mix the mortar according to Method C 91–57 Section 20[6] except that a smaller size batch may be mixed. Weigh 150 g of mortar into each of three waxed paper cups (Note 1).

Insert the wicks to the bottom of the cups taking care not to smear mortar above the scratch line (Note 2). Level the mortar and bring it in uniform contact with the wick. This may be accomplished by using a small clean nonabsorbent object to tamp the mortar in place.

Store the specimens in moist cabinet for 40 to 48 hr. Strip off the paper cup and place the specimen in a No. 463 Pyrex dish with 50 ml of distilled water (Note 3). Cut a slit 45 mm long midway through the center of a 6-in. square piece of rubber dental dam. The wick is about 49 mm wide and when the dam is stretched slightly the slit fits snugly around the wick. Bring the edges of the rubber down over the sides of the dish, stretching slightly and hold in place with a rubber band. Store the specimens under controlled temperature and humidity (mixing room) until the water has evaporated (Note 4).

It takes about 7 days for the water to

evaporate through the wick. Remove the rubber dam and dry the specimen in a constant temperature room for 24 hr. Carefully break the wick from the mortar base and dry at 110 C for 24 hr, cool and weigh to the nearest milligram. Place each wick in 50 ml of distilled water for 24 hr, after which the water is replaced by another 50 ml. After 1 hr replace the water again and continue this procedure until each wick has been washed in 250 ml of water. Again dry the wicks at 110 C for 24 hr, cool and weigh. The difference in weights of the three wicks before and after washing shall be averaged. From this average subtract the average of the blank determinations and round off the result to the nearest milligram. The rounded off result is a measure of the potential efflorescence of the mortar.

Notes:

1. The paper cups are much deeper than necessary and molding the specimen is facilitated by cutting off the top of the cup by cutting down one side from the top and round the cup about midway between top and bottom.
2. The wick may be inserted more readily into the mortar if the cup is supported on a short cylindrical object of such a diameter that it will fit inside the bottom rim of the cups. The wick must extend to the bottom of the cup otherwise the time required for the water to evaporate will be excessive.
3. When the specimens are stored in the moist cabinet there is a tendency for wax and paper to adhere to the mortar when the cups are stripped. It is essential that this be removed and it may be accomplished by using a stiff tooth brush.
4. Moist cabinet—temperature of 73 ± 3 F and relative humidity of not less than 90 per cent. Constant temperature room—temperature of 70 to 75 F and relative humidity of 55 ± 5 per cent.

Suitability of Lightweight Aggregate for Bituminous Plant Mix*

By JOHN C. WYCOFF

Using a reasonably well-graded 0 to $\frac{3}{8}$-in. lightweight aggregate, Hubbard-Field tests as described by the Asphalt Institute and compressive strength tests as specified in ASTM Method D 1074 - 58 T,[1] were performed at varying asphalt content. The results of these tests were highly satisfactory. Hubbard-Field tests of over 3500 lb and compressive strengths of over 350 psi were obtained using 11.0 to 11.5 per cent 85–100 penetration asphalt. The second consideration was the effect of water on bituminous mixtures using this type of aggregate. Mixes tested in accordance with ASTM Method of Test for Effect of Water on Cohesion of Compacted Bituminous Mixtures (D 1075 - 54)[1] showed an index of retained strength to be 89.1 per cent. A field test strip four lanes wide and 200 ft long was placed on route 360 in Richmond, Va., November 19, 1957. This strip was placed using standard manufacturing and laying equipment without encountering difficulty.

LIGHTWEIGHT aggregate suitable for the manufacture of lightweight structural concrete has been useful in saving many tons of deadload in long-span bridges and large structures. Bituminous plant mix manufactured with structural quality lightweight aggregate could prove useful in resurfacing bridge structures where deadload is near critical.

Could a bituminous plant mix be manufactured with a lightweight aggregate that would have the necessary stability and strength to withstand the heavy high frequency traffic of today? Could this plant mix be manufactured and placed with the same equipment that is used with normal weight bituminous plant mix? To answer these questions, an investigation was started in October, 1955. The necessary laboratory test work of this investigation was carried out in the bituminous laboratories of Froehling & Robertson, Inc., in Richmond, Va.

The method of investigation to evaluate the suitability of this aggregate for the manufacture of lightweight bituminous plant mix was carried out in the four following steps:

1. Hubbard-Field stability tests were made in accordance with the method described by the Asphalt Inst. to determine whether good stability could be obtained and, if so, at what optimum asphalt content. These tests were made using 2 by 1-in. molds.
2. Tests run in accordance with ASTM, Method of Test for Compressive Strength of Bituminous Mixtures (D 1074–58),[1] were made to verify the optimum asphalt content as determined in the previous Hubbard-Field tests, and also to study the unconfined compressive strength of this type mixture.
3. Tests were run in accordance with ASTM Method of Test for Effect of Water on Cohesion of Compacted Bituminous Mixtures (D 1075–54).[1] These tests were made at optimum asphalt content as determined by steps 1 and 2 and were made to study, as the method of test implies, the effect of water on bituminous mixes made with this lightweight aggregate.
4. Since the results of steps 1, 2, and 3 were favorable, step 4 is logically a field test where the drying, mixing, and performance of a lightweight bituminous plant mix could be studied.

JOHN C. WYCOFF, after four years in the Army Corps of Engineers, became associated with Virginia Department of Highways where he gained his knowledge of bituminous plant mix. He is at present, employed as Director of Engineering Service with Southern Lightweight Aggregate Corp., Richmond, Va.

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* Presented at the Sixty-first Annual Meeting of the Society, June 22–27, 1958, Boston, Mass.

[1] 1958 Book of ASTM Standards, Part 4.

The aggregate used in all of this investigation was an expanded slate lightweight aggregate manufactured by the rotary-kiln process. The gradation of the aggregate was standard as produced for the manufacture of concrete masonry units, $\frac{3}{8}$ in. to 0 gradation, in accordance with the existing ASTM Specification for Lightweight Aggregates for Concrete Masonry Units (C 331–53 T).[1] This gradation was chosen because it most nearly meets the existing specifications for high-type surface coarse bituminous plant mixes. As this investigation was carried out in the State of Virginia, a comparison is given in Table I of the gradation of the aggregate used with the Virginia Department of Highway specifications for types F-1 and I-3 mixes, the most commonly used surface-coarse mixtures in this state.

While the gradation of the aggregate as used does not completely satisfy either of these specifications, it does approximate both in part and it was felt that this gradation would be suitable for the investigation. The specific gravity of the lightweight aggregate was 1.74 on a bulk basis. A picture of the aggregate graded from $\frac{3}{8}$ in. to No. 4 will give some idea of the vascular nature of this expanded material (Fig. 1).

Hubbard Field Test.—The lightweight aggregate as previously described was tested for stability by the Hubbard-Field method of mix design.[2] As there were no previous data to suggest asphalt contents for this type of material, a reasonable starting asphalt content was derived by dividing 2.65 (normal heavy weight aggregate specific gravity) by 1.74 (bulk specific gravity of the aggregate to be used). This gives a factor of 1.52 which when multiplied by the asphalt content in heavyweight mixes will give the by-weight percentage of asphalt to use with lightweight aggregate mixes. Since the ability of this aggregate to absorb was not known and since it was logically considered to be high, a wide range of asphalt contents was run in the first series.

Table II shows the results of Hubbard-Field stability tests on mixtures ranging in asphalt contents from 9 through 12 per cent with the maximum Hubbard-Field stability being 3860 lb for a mixture containing $10\frac{1}{2}$ per cent asphalt and having a density of 95.1 per cent or a weight per sq yd per in. of thickness of 72.07 lb. As these results are quite respectable, the investigation was continued.

Compression Tests.—Because bituminous plant mixes are sometimes specified on the basis of unconfined compressive strength and because additional data were needed to determine the suitability of lightweight aggregate for bituminous plant mix, tests made in accordance with ASTM Method D 1074–58 T were run at asphalt contents ranging from 10.5 to 12 per cent. The results of these tests are shown in Table III.

It can be seen by a study of the data in Table III that the optimum asphalt content for unconfined compressive strength is 11.5 per cent; 1 per cent higher than that required to reach optimum stability in the Hubbard-Field tests. The unconfined compressive strength test showed that 383 psi was reached at 11.5 per cent asphalt.

Effect of Water.—Since the lightweight aggregate used in this investigation was an expanded slate and this type aggre-

[2] "Mix Design Methods for Hot Mix Asphalt Paving," The Asphalt Inst., Manual Series II, 1st Edition, April, 1956.

TABLE I.—GRADATION COMPARISON.

	Lightweight Aggregate	Type F-1	Type I-3
Per cent passing:			
$^3/_8$-in. sieve	100.0	100	80–100
No. 4 sieve	82.0	75–90	50–70
No. 10 sieve	51.3	60–80	35–50
No. 40 sieve	30.3	15–35	10–25
No. 80 sieve	12.6	5–15	3–15
No. 200 sieve	7.6	2–10	2–10

TABLE II.—MIXTURE PROPORTIONS AND TEST RESULTS.

Test mixture	V-1	V-2	V-3	V-4	V-5	V-6	V-7
Aggregate, per cent	91.0	90.5	90.0	89.5	89.0	88.5	88.0
Bitumen, per cent	9.0	9.5	10.0	10.5	11.0	11.5	12.0
Stability, lb	3522	3618	3725	3860	3670	3598	3397
Bulk, specific gravity[a]	1.518	1.527	1.532	1.540	1.547	1.562	1.553
Theoretical specific gravity	1.636	1.631	1.625	1.620	1.615	1.610	1.604
Density, per cent	92.8	93.6	94.3	95.1	95.8	97.0	96.8
Weight, lb per sq yd per 1 in. thick	71.04	71.46	71.70	72.07	72.40	73.10	72.68

NOTE.—There was evidence of aggregate crushing during molding of test specimens. Above results are averages of six specimens for each bitumen content. 85–100 penetration asphalt was used.

[a] Hubbard-Field stability 2 by 1-in. molds.

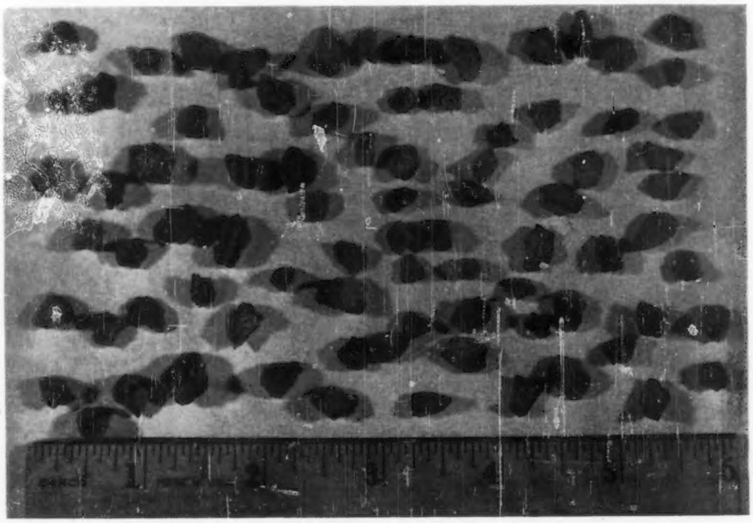

Fig. 1.—Vascular nature of the lightweight aggregate.

TABLE III.—UNCONFINED COMPRESSIVE STRENGTH TESTS.

Test mixture	V-a	V-b	V-c	V-d
Aggregate, per cent	89.5	89.0	88.5	88.0
Bitumen,[a] per cent	10.5	11.0	11.5	12.0
Strength, psi	366	372	383	352
Bulk, specific gravity	1.520	1.525	1.533	1.550
Theoretical specific gravity	1.620	1.615	1.610	1.604
Density, per cent	93.8	94.4	95.2	96.6
Weight, lb per sq yd per 1 in. thick	71.1	71.4	71.7	72.5

[a] Above results are average of four specimens for each bitumen content. 85–100 penetration asphalt used in these tests.

gate has a comparatively high ability to absorb water (approximately 15 per cent by weight), the strength after immersion in water was determined in accordance with ASTM Method of Test for Effect of Water on Cohesion of Compacted Bituminous Mixtures (D 1075 – 54). These tests were made at the optimum asphalt content 11.5 per cent, as determined by the unconfined compression tests. The average results on four samples, both soaked and unsoaked, were as follows: unconfined compressive strength was 382 psi for unsoaked samples and 340 psi for soaked samples; retained strength was 89.1 per cent.

Field Tests.—On November 19, 1957, the original field test of lightweight asphaltic plant mix was made. The mix was placed on a 200-ft strip four lanes wide just east of Magnolia Avenue on route 360 in Richmond, Va., with the full cooperation of the engineers of the City of Richmond.

The plant itself was the normal batch-type plant, having a 5000-lb batch hopper and pug mill. This type of plant represents average plant conditions and would establish whether lightweight aggregate could be handled satisfactorily.

General Field Observation

Drying.—There was some difficulty encountered in the drying of the material for this field test. However, the weather had been extremely wet and as the aggregate had been stockpiled in the open it was completely saturated. This need not be the case in a production job of lightweight asphaltic plant mix as the material can be shipped from the plants in a reasonably dry condition. Even though the aggregate was completely saturated, it was dried satisfactorily.

Batching and Mixing.—Due to the reduced weight of the lightweight aggregate, the batch-size was reduced from 5000 lb (the normal heavyweight capacity of the weight batch hopper and the pug mill) to 3000 lb when batching and mixing the lightweight aggregate. This proved to be completely satisfactory and no difficulty was encountered either in the size of the weight batch hopper, the size of batch in the pug mill, or the mixing action in the pug mill.

Placing.—The lightweight asphaltic plant mix was placed as resurfacing on an old concrete pavement with a Blaw-Knox paving machine and rolled with both 5-ton and 10-ton rollers. The 5-ton roller was first used because it was felt that there might be some crushing of the aggregate under the roller. However, since no aggregate crushing occurred with the 5-ton roller, the 10-ton roller was put into use. There was still no aggregate crushing and the mix rolled very well. The lightweight asphaltic plant mix looked and worked like a good normal weight asphaltic plant mix.

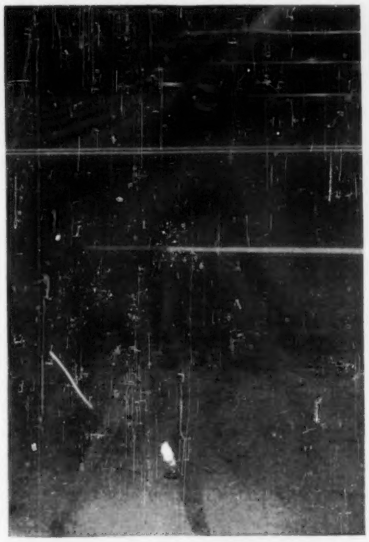

Fig. 3. Lightweight aggregate plant mix and heavy aggregate plant mix. Lightweight mix is on left.

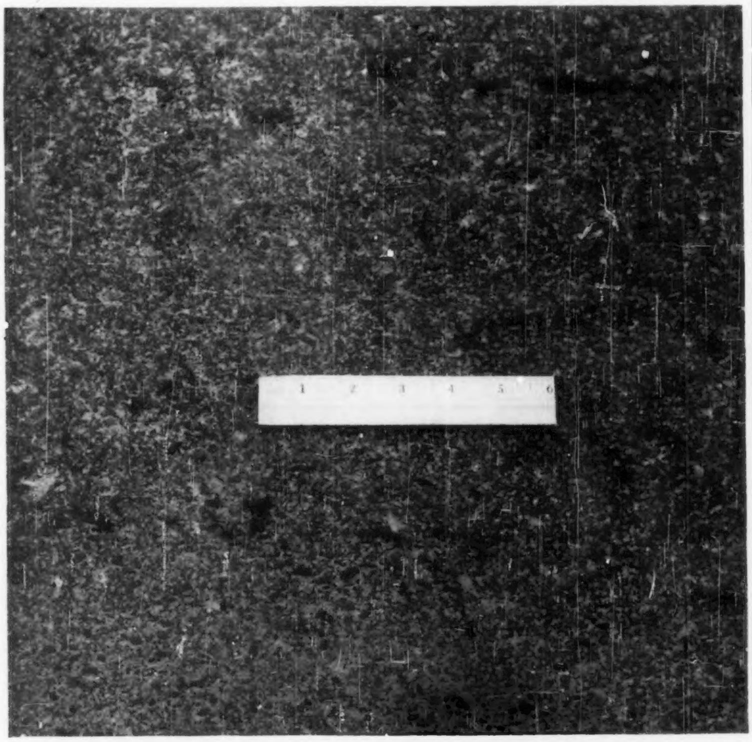

Fig. 2.—Lightweight bituminous plant mix after six months service.

Initial Tests of Lightweight Asphaltic Plant Mixes as Placed in the Roadway

The plant mix sampled from the trucks as they left the plant showed the following gradation with 11.2 bitumen content:

Sieve Size	Per cent Passing
$\frac{3}{8}$-in.	100.0
No. 4	82.0
No. 10	47.0
No. 40	13.3
No. 80	6.6
No. 200	2.2

Hubbard-Field stability tests of this mix made at one laboratory showed a stability of 3242 lb and a density of 1.66 for an average of six specimens. Tests in a second laboratory showed an average Hubbard-Field stability of 3313 lb and a density of 1.66 for sets of three specimens.

Immersion compression tests made in accordance with ASTM Methods D 1078 – 55 T and D 1075 – 54 on sets of nine specimens by the first laboratory showed that the unsoaked specimens had an unconfined compressive strength of 570 psi and the soaked specimens had an unconfined compressive strength of 466 psi. This gave a retained strength of 81.7 per cent and a density of 1.62. The same mix when tested by the second laboratory on sets of six specimens showed an unsoaked unconfined compressive strength of 587 psi, a soaked unconfined compressive strength of 450 psi which gave a retained strength of 76.7 per cent and a density of 1.61.

Between the dates of November 19, 1957, and May 23, 1958, this pavement was exposed to very severe weather conditions. Precipitation totaled 30.27 in. The average number of vehicles per day for this route is 12,769, or moderately heavy. The pavement at the time of this report was in excellent condition. It will remain under continuous observation (Figs. 2 and 3).

Conclusions

1. Lightweight aggregate showed good stability when tested by the Hubbard-Field method at a reasonable asphalt content.

2. Unconfined compressive strengths of lightweight aggregate mixtures were very good.

3. Immersion compression tests showed lightweight aggregate bituminous plant mix to have good retained strength.

4. Field tests have shown that lightweight aggregate can be successfully handled with normal equipment and produce good bituminous plant mix.

5. Structural grade lightweight aggregate is suitable for lightweight asphaltic plant mix.

DISCUSSION

Mr. Paul F. Phelan.[1]—How about the skid resistance?

Mr. J. C. Wycoff (*author*).—That has not been checked as yet.

Mr. W. B. Warden.[2]—The percentage of asphalt by weight is appreciably higher, but it seems to be about normal when expressed as per cent by volume. Are there any figures on that?

Mr. Wycoff.—A ton of normal heavyweight pavement will cover approximately 19 sq yd per in. thick, but lightweight aggregates will cover 28 to 29 sq yd. The asphalt content, by weight, is considerably higher, but by volume, it is approximately $1\frac{1}{2}$ per cent than that for heavy weight aggregate.

Mr. J. Eldridge Wood.[3]—I wonder whether the author found a consistent pattern of decreasing specific gravities from small particles to maximum size. We found in some experiments that as the sizing decreases, the specific gravity increases. That would disturb the gradation. Would not a correction have to be made to compensate for that?

Mr. Wycoff.—Lightweight aggregates do vary in specific gravity with particle size. The smaller the particle size, the heavier the gravity. A change in gradation will change the specific gravity, or what appears to be specific gravity, but the variation for a small variation in gradation is not significant.

Mr. R. A. Chisholm.[4]—The Corps of Engineers pays for pavement on a weight per square yard basis which is based on a penalty for aggregates above 2.70 apparent specific gravity and a recapture clause to the contractor for aggregates under 2.60 apparent specific gravity. This, in effect, is payment for pavement on the square yard basis.

Mr. G. L. Oliensis.[5]—Was it necessary to heat the wet aggregate longer in the driers than it would have been necessary to heat ordinary aggregate under the same conditions?

Mr. Wycoff.—I think this would take another investigation. It is my assumption that the aggregate, if it was not completely saturated, would dry reasonably well. It was dried with normal drying equipment, but it was hard to do and it took a great deal of time. If the aggregate had been stockpiled dry, it would not have given that trouble.

Mr. Oliensis.—Was it noted whether the asphalt that was used to coat the aggregate foamed or had a tendency to run off the rock, as it was being mixed with the aggregate?

Mr. Wycoff.—This was not observed. The appearance showed it to have an excellent coating.

Mr. W. H. Goetz.[6]—I think that the author should be congratulated on this very interesting piece of work. Lightweight aggregate has been tried with bituminous materials in other places, but this to my knowledge is the first report of such an investigation in the form of a technical paper.

I point out that the field results are on the basis of a year's service. This is hardly sufficient time for evaluation, so I hope the author will favor us with a report after a further time of service.

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[3] State Roads Commission, Bureau of Soils and Materials, Baltimore, Md.
[4] Supervisory Materials Engineer, Corps of Engineers, U. S. Army, Sausalito, Calif.
[5] Director of Research, Lloyd A. Fry Roofing Co., Summit, Ill.
[6] Research Engineer and Professor, School of Civil Engineering, Purdue University, Lafayette, Ind.

Extending Concrete Highway Durability and Light Reflectance with Silicones*

BY HAROLD L. CAHN and ROYAL V. MACKEY, JR.

SECOND only to safety, in the design and construction of today's modern concrete highways, is the consideration of durability.

While the use of silicones in concrete highways can have a definite bearing on the safety factor also, as will be brought out later in this paper, the principal subject under discussion is durability—resistance to the ravages of the elements as well as to the wear and tear of an ever-increasing traffic load.

The best engineered concrete highway, constructed of the best materials, may be vulnerable not only to severe weather but also to the chemical expedients used to keep the highways safe and passable during snow and ice conditions.

Since some of the heaviest traffic areas are located geographically where the damaging effects of severe winter weather and of climatic extremes are encountered, these highways must be kept open and must be resistant to the chemicals used to keep them open.

Salts and periodic freezing-and-thawing cycles can and do raise havoc with unprotected concrete roads. Since the cost per mile is currently at the highest level in history, it behooves us to give major attention not only to building good roads to bear the burden of traffic, but also to treating these highways in whatever manner at our disposal that will keep expensive maintenance at an absolute minimum.

Silicone chemicals have proven beneficial in reducing the damage to concrete from weather and ice-melting chemicals. The most effective, and simultaneously the most economical type of silicone for this purpose is the water soluble product, sodium methyl siliconate, at an optimum concentration of 2 per cent silicone solids.

From the early days in the history of silicones, when it became apparent they possessed the property of imparting water repellence to masonry, silicones were regarded as having considerable potential in concrete highway construction and maintenance—preventive maintenance that is, in contrast to the less desirable and more costly corrective maintenance.

Since that time, more than five years ago, large amounts of development effort and money have been spent in evaluating these materials in the laboratory to prove their worth in highway work, prior to actual field applications.

In order to determine that the treatment would be effective over a wide range of concrete surfaces, mixes of various proportions were prepared from both type I portland cement (non-air-entrained) and type IA portland cement (air-entrained). Some mixes tested included natural cement blended with the portland cement. Job site mixes were included in the tests as well as laboratory mixes.

The laboratory mixes consisted of cement and sand. The job site mixes included also coarse aggregate (Table I).

All of these laboratory mixes were cast into blocks and cured by storage for 24 hr in the mold followed by 6 days out of the mold, all at 90 per cent relative humidity. All specimens were then dried in air to constant weight in the laboratory at 70 to 75 F and 50 to 60 per cent relative humidity. The specimens from job site mixes were cast in the same manner, but in order to simulate field conditions, they were cured for 6 days under moist burlap, prior to drying in air.

TABLE I.—TYPICAL CEMENT MIXES USED IN LABORATORY TESTS.

Mix[a]	Type I Cement	Type IA Cement	Cow Bay Sand	Run of Bank Sand
BA...	...	1	5	...
BC...	1	...	5	...
B.....	1	...	...	6
C.....	...	1	6	...
D.....	1	...	6	...

[a] Cement-water ratio in all mixes was 1:1.

Various methods of applying silicones to these blocks—brushing, dipping, and spraying—were investigated before adopting the immersion method as most useful in the laboratory.

The first objective was the determination of the degree to which this treatment would repel water, thus minimizing the absorption of water into the concrete. Extensive tests made in the laboratory indicated definitely that silicone-treated concrete absorbed only a small fraction of the water that was soaked up by untreated specimens (Table II).

ROYAL V. MACKEY, JR. graduated from Lehigh University and joined General Electric Co. after six years' service with U. S. Army Ordnance Department. He has been associated with the Silicone Products Department for over ten years and has had experience in manufacture of silicone chemicals and uses for these materials in treatments of various types of surfaces. He is currently employed as a technical sales representative.

HAROLD L. CAHN, technical service specialist, Silicone Products Department, General Electric Co., Waterford, N. Y., is responsible for sales service and application development of silicone products in the protective coatings industry, in which he has worked in several capacities since 1937.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Sixty-first Annual Meeting of the Society, June 22-27, 1957.

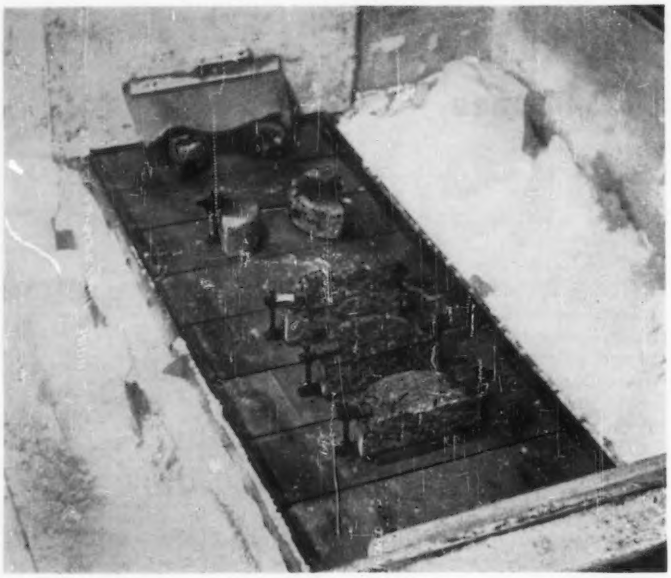

Fig. 1.—Interior of freezing chamber showing specimens mounted on moving aluminum alloy belt.

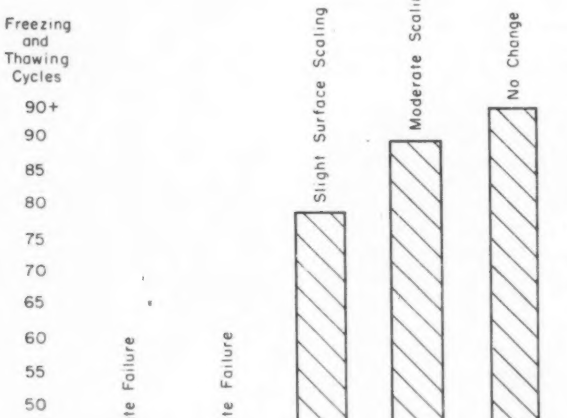

Fig. 2.—Freezing-and-thawing stability.

Type I...... Type I portland cement concrete, no treatment.
Type I-O.... Type I portland cement concrete, treated with petroleum distillate.
Type I-S.... Type I portland cement concrete, treated with silicone.
Type IA.... Type IA portland cement concrete, no treatment.
Type IA-S... Type IA portland cement concrete, treated with silicone.

Extensive testing was next inaugurated to determine the extent to which this water repellance could be translated into improved resistance to freezing and thawing damage. Similar specimens to those used for water absorption tests were prepared and cycled in a rapid freezing-and-thawing apparatus which was fitted with a water supply to soak the specimens immediately before they entered the freezing chamber. This apparatus is shown, with the cover removed, in Fig. 1.

The presoaked specimens passed through the freezing chamber in 1 hr, during which they were chilled by dry ice to 0 F. This was followed by 1 hr in air at room temperature, 1 hr in water at 50 F followed by 1 hr in room temperature air before being wetted as they again entered the freezing chamber. This method is modeled after ASTM Tentative Method C 291–57 T.[1]

TABLE II.—CROSS-SECTION OF WATER ABSORPTION TESTS.

Material	Treatment	Per Cent Water Absorption		
		24 hr	72 hr	165 hr
Portland cement mortar...	None	6.5	...	...
Portland cement mortar...	2 per cent silicone	2.3	...	...
Slag block..	None	3.1	...	...
Slag block..	2 per cent silicone	0.6	...	...
Concrete block.....	None	...	6.0	...
Concrete block.....	2 per cent silicone	...	0	0.5

These tests brought out distinct differences between the silicone-treated specimens and those not so treated. Specimens prepared from non-air-entrained cement and not treated with silicone failed completely by disintegration within 35 to 40 cycles. Similar, but oil-treated, specimens, tested as controls, failed just as badly in the same length of time. Silicone-treated blocks, containing non-air-entrained cement, showed only slight surface scaling in 75 to 90 cycles (Fig. 2).

Test blocks prepared from air-entrained cement, but untreated, fared much better than their non-air-entrained counterparts. The use of air-entrainment greatly improves the resistance of portland-cement concrete to this sort of damage, but in the rigorous environment of ice-removing salt, even the air-entrained concrete can be made substantially more resistant to scaling

[1] Tentative Method of Test for Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water (C 291 – 57 T), 1958 Book of ASTM Standards, Part 4.

by a silicone treatment. The untreated specimens exhibited only moderate scaling after 90 cycles. Similar, treated specimens were essentially unchanged after the same number of cycles. These differences are illustrated in Fig. 3. The blocks shown in the lower part of the figure were made with non-air-entraining while the others contained air-entraining cement. At the right are untreated specimens (*b*) and at the left (*a*) are those that were silicone treated. Note that while the air-entrained cement has effected a pronounced improvement, without benefit of silicone treatment, this specimen (upper right) still exhibits some scaling which is absent in its treated counterpart (upper left).

The really marked improvement imparted by silicones to air-entrained concrete will be appreciated when the effects of salt are added to the rigors of the freezing-and-thawing cycling. When rock salt was applied to the iced surface of the specimens each time they emerged from the freezing chamber, the untreated blocks of air-entrained concrete began to show definite surface scaling after only 10 cycles. The silicone-treated ones, however, exhibited no indication of scaling after 20 cycles (Fig. 4).

Finally, water absorption tests were made on treated specimens which had been subjected to 25 freezing-and-thawing cycles. These blocks still absorbed less than 1.5 per cent of their own weight of water. This is in contrast to an initial absorption of 8 to 10 per cent, and indicated substantial durability of the treatment.

Mechanism of Silicone Protection: Silicone protection is due to two factors. First is the silicones' inherent repellency of water. Second, it is the ability of the silicone chemical, in diluted solution, to penetrate into the pores of masonry and to line those pores with silicone. Figure 5 illustrates this penetration which may vary from $\frac{1}{16}$ to $\frac{1}{4}$ in., depending upon the porosity of the masonry. The figure shows halves of treated blocks—one *a*, of concrete, and the other, *b*, of mortar. Just before being photographed, the broken faces were dipped into water. The depth of penetration of the silicone into each type of masonry is indicated by the light border which was not wetted by the water.

Field Tests: Through the cooperation of several state highway and toll road authorities, field test applications were made in several areas. Even though silicones had been applied to highway surfaces in the past, the first application to new highway construction was made on the New York State Thruway in the Albany area. While most of the test area was treated with a 2 per cent silicone solids solution, which was the optimum concentration established in the laboratory, one section was treated, at the same coverage rate of 100 sq ft per gal, but with a 0.5 per cent silicone solids solution. Observation and retreatment, two years later, yielded two important facts:

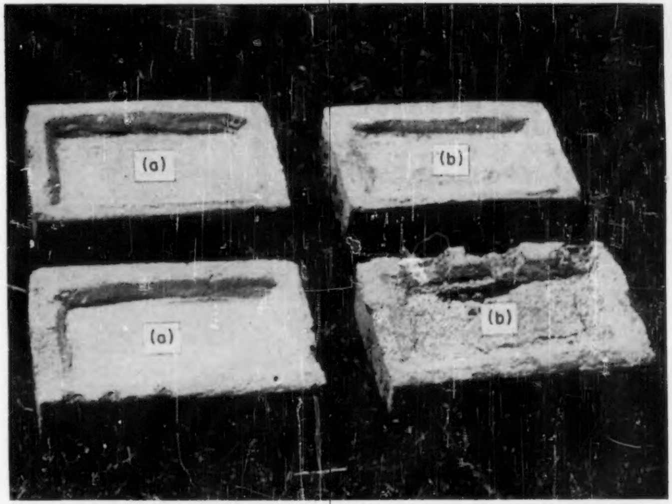

Fig. 3.—Effect of multiple freezing-and-thawing cycles on silicone treated (*a*) and untreated (*b*) concrete blocks. Air-entrained concrete at the top; non-air-entrained at the bottom.

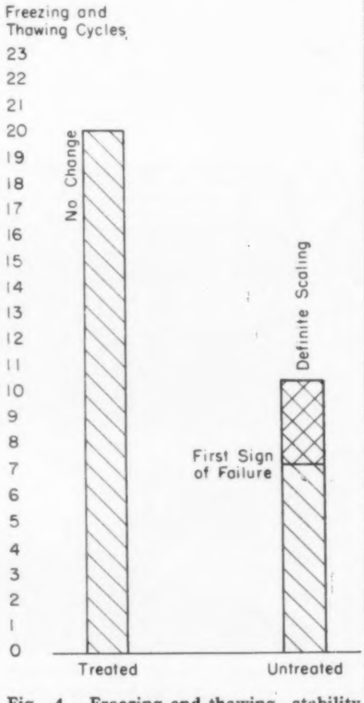

Fig. 4.—Freezing-and-thawing stability with rock salt. Mix C from Table I.

1. The color of the 2 per cent treated panels was very much lighter, when wet, than that of untreated areas.

2. In retreating the section that had the low concentration coating, the application rate was the same as was used previously—100 sq ft per gal. In contrast, those panels that had received the optimum 2 per cent treatment would not accept the retreatment at this rate. It was necessary to apply it at the rate of 150 sq ft per gal since the prior treatment was still effective in imparting a high degree of water repellence.

Inasmuch as all of these roadway test panels were of air-entrained concrete and the exposure was of relatively

Fig. 5.—White border indicates depth of penetration of silicone in concrete (*a*) and into mortar (*b*).

short duration (2 yr), they had not begun to exhibit differences in degree of deterioration.

On the other hand, a similar 2 per cent silicone solids treatment was applied to all of the curbing, except one small section, of a New York state highway bridge. Two years later, all of this treated non-air-entrained concrete curbing was in perfect condition, but the untreated section was seriously deteriorated by spalling.

Figure 6 shows the spray rig that was used to make field scale applications to the pavement and bridge decks. No high pressure is used inasmuch as it is desirable to flood the surface with the solution so as to insure maximum penetration.

Other highway applications have been made on the Wilbur Cross Parkway in Connecticut, Garden State Parkway in New Jersey, on U. S. Highway 16 in Wisconsin, and on State Highway 2 in Massachusetts.

In the Massachusetts test, on a concrete bridge deck, only slight scale formation was reported after more than 2-yr exposure, while untreated control areas were reported to exhibit considerably more scale.

In Wisconsin, after more than 2-yr exposure on a bridge deck, there is no scaling or spalling. While in this short space of time there is no marked difference in deterioration, it is reported that the treated area still exhibits a distinct water-repellent condition. In this state, particular attention is being given to the usefulness of a silicone treatment in the prevention of spalling and scaling resulting from the use of ice-removing salts. During the 1957 construction season, several large projects were undertaken to evaluate fully the effectiveness of the silicone treatment. The total area treated in these several projects, including both bridge decks and pavement surfaces, totaled some 19,000 sq yd.

In addition to the traveled surfaces, other concrete structures directly associated with highway construction are equally in need of protection. Curbing along bridge decks has been mentioned in connection with tests made on the New York State Thruway. Toll booths, maintenance structures, parapets, abutments, bridge fascia, and piers are all subject to deterioration by weather and exposure to salt solutions. This wear and tear, however, can be greatly minimized by treatment with silicones. For example, a part of the fascia and the center pier of a Thruway bridge, shown in Fig. 7, were treated with a 2 per cent silicone solids solution. This photograph was taken immediately following an all-night rain. The much lighter color of the center pier contrasts with the other piers which are thoroughly water-soaked. There is also a sharp line of demarcation in the fascia just to the left of that pier. The light area to the right was treated while the area to the left was not. It is true that these areas may not be as vulnerable as traffic surfaces, but other locations likewise might well be protected from the weather.

Reflectance: Apart from its effect on durability, in such areas as on abutments, and certainly on the pavement and bridge deck surfaces is the greatly enhanced safety that results from the silicone treatment. As shown in the last illustration, by minimizing the absorption of water into the concrete, the silicone was effective in preserving the pale color of dry concrete, thus retaining a light reflectance of very nearly that of the dry masonry. When this is contrasted with the 35 to 50 per cent reduction in light reflectance from an untreated wet concrete surface, the added safety factor, due to markedly enhanced visibility, especially at night, becomes obvious.

The great contrast between light reflectance of untreated and silicone-treated wet concrete is shown in Fig. 8. These reflectance measurements were

Fig. 6.—Spray rig used to apply silicone solution to highway surface.

Fig. 7.—Center pier of bridge and part of fascia showing line of demarcation where silicone treatment ended. Shown after all-night rain.

Note pale color of treated center pier and of right side of fascia.

obtained using a test method described in the American Standards Practice for Street and Highway Lighting.[2]

Requirements for water soluble silicones are now included in specifications for concrete highway treatment. The specifications for water-soluble silicone (for concrete surface treatment) have been in effect in the New York State "Public Works Specifications"[3] for well over a year. A more recently written specification for a similar type material has been issued by the State of Wisconsin Highway Department. These are the first, to our knowledge, who have determined in their own tests that silicones can be advantageous in the preventive maintenance of concrete highways and structures.

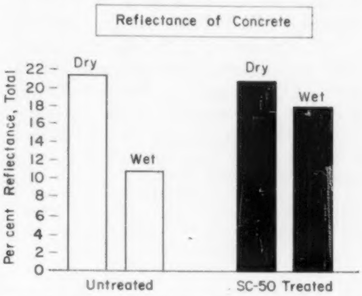

Fig. 8.—Contrast in reflectance between silicone treated and untreated concrete when wet.

[2] (ASA A 12-1), Am. Standards Assn. (1953).

[3] Public Works Specifications, State of New York Department of Public Works, Division of Construction, M-41X, Jan. 2, 1957, p. 119.

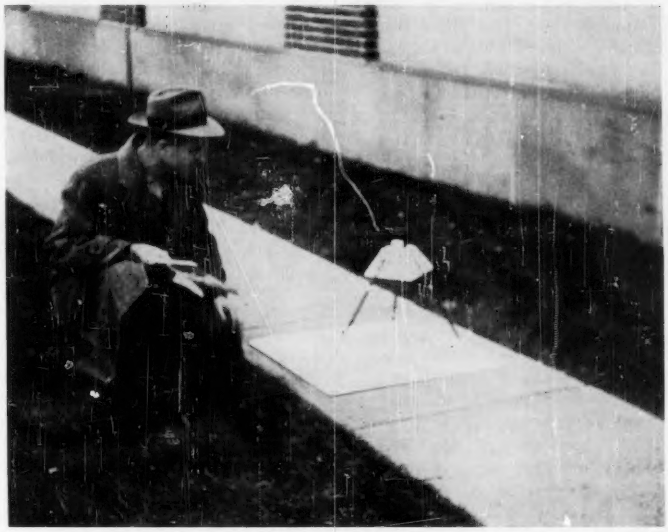

Fig. 9.—Foot-candle meter being standardized prior to taking readings.

DISCUSSION

A Member.—How dry does the concrete have to be to apply the silicone? How do you tell when it is dry enough? Also, does the pH value have any affect on it?

Mr. H. L. Cahn (Author).—Concerning the first question—about how dry it needs to be—it does not have to be absolutely dry inasmuch as we are applying a water solution provided the concrete is not so wet that the surface is visibly covered with water. If the surface is damp or dry, the material can be applied, but it should be remembered that appreciable water in the concrete dilutes the chemical. This is in contrast to some solvent-based silicone compounds which must be applied to dry surfaces, but the chemical that I was discussing is in water solution and can be applied to a damp surface.

The pH would not matter greatly inasmuch as I do not believe we have many acid concretes; and the pH of the silicone chemical under discussion is rather high—quite an alkaline solution. Therefore, an alkaline concrete would make no difference in the use of this material.

Mr. Michael Dranichak.[1]—The state of Missouri has issued a specification—not for the water-soluble but for the solvent-type silicones that the primary three silicone manufacturers make. New York State is amending the specification to include the solvent-type silicone.

The author's statement that the solvent-type cannot be applied over a damp surface does not appear to hold true. It has been applied over damp surfaces. The absorptive forces seem greater than the force between the water and the silicate interface. The washing action of the solvent and the absorptive force of the silicone permit the application of a solvent-type silicone over a damp surface.

We also would recommend that you do not apply either water-soluble or petroleum solvent over a saturated substrate. If this is done proper penetration is not obtained. As the water content of the concrete increases, the depth of penetration decreases whether using a solvent-type or a water-soluble type of silicone.

Mr. H. P. Hatch.[2]—I would like to ask at what age should the concrete silicones be applied? If the road had been in use, how much cleaning would have to be done before you could apply it?

Mr. Cahn.—The optimum application time is after the curing compound (the membranes) have been removed or abraded off and before the road is open to traffic. It is obvious that this cannot be done in all cases, but this would be most desirable. On a road that has been open to traffic for a time and is pretty well oil-coated—and the center of the lane is pretty well oil- and dirt-coated—this should be fairly well cleaned because the aqueous treatment will not penetrate the concrete unless the surface is free of oil.

Mr. Paul Klieger.[3]—I should like to comment on the few field exposures that were cited. There was considerable intermixing, it seemed to me, of references to treated surfaces—in one case air-entrained concrete for which no visible differences in surface durability were apparent; in another case a reference to applications to non-air-entrained

[1] Technical Service, Union Carbides Silicones, Buffalo, N. Y.

[2] Concrete Engineer, Am. Electric Power Co., New Haven, W. Va.

[3] Senior Research Engineer, Applied Research Section, Research and Development Laboratories, Portland Cement Assn., Chicago, Ill.

concrete curbing. Then there were some references to a considerable number of projects in which concrete had been coated in the recent past, with no distinction as to whether these were air-entrained concretes or not. My question is this: Has there been any conclusive field evidence to indicate that silicone treatment will benefit air-entrained concrete, which has an 18 to 20-yr excellent field exposure record?

Mr. Cahn.—We do not have that as yet because the treatments on air-entrained concrete in the field tests are only about two years old, and differences have not begun to show up as of this time. The benefits imparted to air-entrained concrete are based on laboratory tests thus far. However, lest it be inferred that we are trying to discredit air-entrained concrete, I want to point out that the subject matter was intended to cover improvement of concrete—not differentiating between air-entrained and non-air-entrained—but as far as we have been able to determine to date, we were only able to get laboratory results. We wanted to point out that there was some benefit (even though it might be small) that air-entrained concrete could derive from this type of treatment.

Mr. H. L. Cahn (*Author's Closure*).—Mr. Dranichak characterized the solvent-type silicone as the material exemplified by "the solvent-type silicones that the three primary silicone manufacturers make."

We (the authors) cannot agree that this type silicone can be applied with impunity to a damp surface.

For an additional, and impartial, opinion on this subject we consulted Mr. H. B. Britton of the New York State Department of Public Works, Division of Construction, Bureau of Bridges. Mr. Britton has had considerable experience with silicone treatment of concrete highways and structures. On the basis of that experience, he concurred completely with our opinion that the solvent type silicone should be applied only to a dry concrete surface.

False Negative Permanent Strains Observed with Resistance Wire Strain Gages

By CLARENCE J. NEWTON

In connection with a project that involved the determi·ation of the elastic limit of specimens of steel by means of electrical resistance strain gages, it was observed that below the yield point the resistance gages often indicated strains upon release of the load that were oppositely directed to the preceding load. Comparison with permanent strains observed with optical gages on the same specimen showed that in this case the negative strain was a false indication of the resistance gage.

The sensitivity of commercial instruments for use with resistance wire strain gages is sufficient to permit strain measurements to about 2×10^{-6}. However, variation in gage factor, nonlinearity, hysteresis, and zero shift in the gages limit the accuracy of the measurements unless the gages can be calibrated after mounting. Campbell (1)[1] made an extensive study of 15 types of gages, particularly in regard to nonlinearity, hysteresis, and variation from mean gage factor. His data also show that most of the gages exhibited a negative zero shift due to loading; that is, as the load was decreased, the gage indicated zero strain before the true strain had returned to zero.

In studies of elastic limit, such as those of Muir, Averbach, and Cohen (2), it is important to know the error caused by zero shift, since the determinations are based on residual strain remaining after release of load. In a project now under way in the Mechanical Metallurgy Section of the National Bureau of Standards, measurements of this type produced questionable results. Since the behavior of resistance wire gages under these conditions does not appear to be well recognized, it was thought that some of the data obtained in this investigation would be of general interest.

Observations of Permanent Strains

The specimens on which the gages were used were made of 1020 steel, rectangular in cross-section, with a total length of $7\frac{1}{2}$ in. and a 1-in. long gage section with dimensions of 0.625 by 0.343 in. They were annealed for 30 min at 1610 F, followed by slow cooling. A series of tests was run with loads of

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

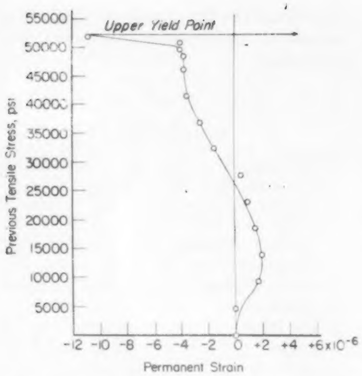

Fig. 1.—Permanent strain indicated by electrical resistance strain gages after release of increasing previous stresses on an annealed specimen of 1020 steel tested in tension.

each sign in a hydraulic testing machine of 30,000-lb capacity. For the series in tension, the specimens were held in Templin grips; for the series in compression, they were confined by specially designed, well-lubricated guides. The loads were applied stepwise with intervening periods of no load as in the work of Muir, *et al.*

The strains were measured by means of SR-4 electrical resistance wire strain gages, type A-3, having a nominal gage length of $\frac{13}{16}$ in., in conjunction with a portable strain indicator. The gages were attached to the narrow surfaces of the reduced section of the specimen, using a common household cellulose cement diluted with acetone. The surfaces were smooth and had been cleaned in accordance with standard strain gage techniques. Finger pressure was applied to the gage for about 1 min, and the installation was allowed to dry, in some cases with heat, for a minimum of 3 days before a test was run. Two gages, on opposite sides of the specimen, were connected in series so as to balance out bending strains, which did sometimes appear in small degree. Another pair of gages was mounted on a dummy specimen of the same material for ambient temperature compensation. In order to eliminate the effect of indicator drift, readings were made in each unloaded state with the active and dummy gages connected in the normal manner and then with the gages interchanged. The absolute values of strain thus obtained were averaged.

The load was applied to the specimen at a crosshead speed of about 0.03 in. per min. After the load had reached a predetermined value, it was quickly released and the two readings of the strain indicator were made in the course of a few minutes. Then a new loading cycle began. The load was carried to a higher final value, then quickly dropped to zero, and new strain readings were made. This process was usually carried past the yield point until a total permanent strain of about 3 per cent was reached. The indicator readings with load released, in conjunction with the original balancing readings, allowed calculation of the no-load strain or permanent set, if any, after the particular preceding load.

Figure 1 shows the permanent strain measured after releasing each increment of load on an annealed specimen tested in tension. There is first a small positive strain, then a slowly increasing negative strain, followed by a relatively large value of negative strain until finally yielding of the specimen occurs with a very large value of positive strain, which cannot be shown on the graph. Figure 2 shows the complementary behavior of an annealed specimen tested in

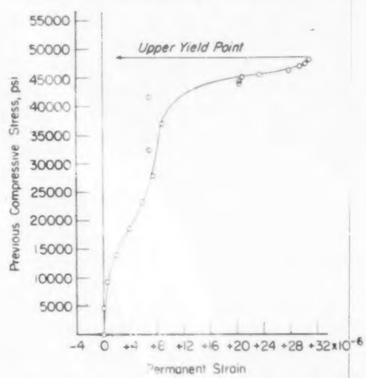

Fig. 2.—Permanent strain indicated by electrical resistance strain gages after release of increasing previous stresses on an annealed specimen of 1020 steel tested in compression.

compression. The small positive permanent strains (extensions), the large positive strain, and finally compressive yield of the specimen can readily be observed. The maximum inverse strain in this case, about 29×10^{-6}, was rather higher than typical, but qualitatively similar results were obtained with all annealed specimens tested. Tests with resistance strain gages were made also on eight specimens that had been plastically deformed several per cent before the gages were applied. In five of these cases, significant changes in permanent strain were observed that were opposite to the applied strain. Similar indicated negative permanent strains were also observed with specimens of cartridge brass.

Because these observations seemed rather strange, it was decided to repeat some of the tests using optical strain gages instead of the resistance gages. A pair of 1-in. gage length Tuckerman gages (**3**) with autocollimators were used, one on each side of the specimen. An annealed specimen was stepwise loaded and unloaded in tension under the same conditions as those previously used. The optical strain gages revealed a slowly increasing positive permanent strain beginning immediately after release of the lowest load and increasing after each increased load, until yielding occurred at a stress of about 50,000 psi. This behavior, graphically represented in Fig. 3, was quite contrary to that observed with annealed specimens tested in tension with resistance strain gages.

To substantiate the results, another annealed specimen was tested in tension with resistance strain gages. The stepwise testing was carried out until a definite indication of negative permanent strain was observed. The testing was stopped well below the yield point. This test was then repeated and stopped again as soon as definite negative strain was observed. The previous loadings of the gages in the first test did not prevent the appearance of negative permanent strains in the subsequent sequence of loadings. It has been reported (**4**), however, that gage stability is improved by cycling a gage to its maximum load several times. Finally the resistance gages were removed from the specimen and the test was repeated on the same specimen with optical strain gages, in which case no negative permanent strains were observed. This third run was carried to the yield point, which occurred at a stress of about 53,000 psi. The observed permanent strains in the three cases are presented in Fig. 4. It appears that for released loads up to about half that required for yield, both types of gages indicated small positive permanent strains of comparable magnitude. As the loads be-

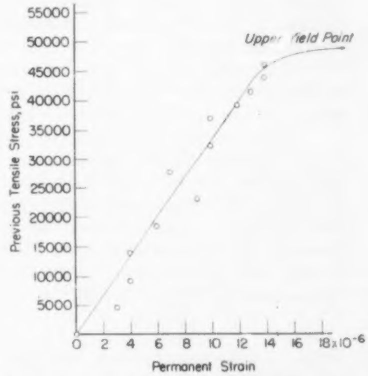

Fig. 3.—Permanent strain indicated by optical strain gages after release of increasing previous stresses on an annealed specimen of 1020 steel tested in tension.

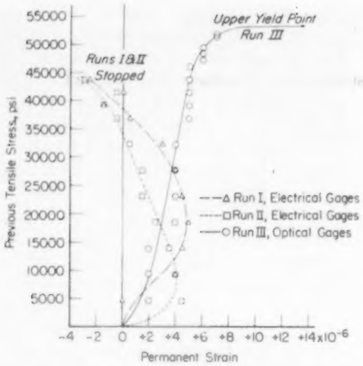

Fig. 4.—Permanent strain indicated by electrical resistance gages and by optical gages after release of increasing previous stresses on a specimen of 1020 steel, initially annealed, tested in tension.

came larger, the optical gages indicated an increasing permanent strain which ran smoothly into the yield phenomenon. The resistance gages, however, indicated a decreasing permanent strain which soon became negative, and would presumably have reached a maximum in the negative direction just before the positive yielding, if the behavior coincided with that of similar annealed specimens taken as far as the yield point.

Discussion

Although these tests were not made under conditions of carefully controlled temperature and humidity, it appears that the results indicate behavior typical of resistance gages mounted with cellulose cement. These indicated negative permanent strains are similar to the negative residual strains often observed with X-rays in plastically deformed metals (**5**). The usual explanation of the latter phenomenon is based on the assumption of plastic flow in parts of the metal and elastic behavior in other parts. Perhaps further studies of the behavior of resistance strain gages might result in an explanation of their indicated negative permanent strain that would involve creep somewhere in the gage or its bonding cement in a manner analogous with the mechanism for residual strain in metals. Regardless of the possible explanation, however, the error in the observed strain values, particularly just prior to yielding, make it inadvisable to use resistance gages with this technique for the determination of permanent strains of the order of 10^{-5} or smaller.

References

(**1**) William R. Campbell, "Performance Tests of Wire Strain Gages, I—Calibration Factors in Tension," *Technical Note*, No. 954 (1944) and "II—Calibration Factors in Compression," *Technical Note*, No. 978 (1945), National Advisory Committee for Aeronautics.

(**2**) H. Muir, B. L. Averbach, and M. Cohen, "The Elastic Limit and Yield Behavior of Hardened Steels," *Transactions*, Am. Soc. Metals, Vol. 47, pp. 380–407 (1955).

(**3**) J. H. Maulbetsch, "Optical Methods of Strain Measurement," M. Hetenyi, Handbook of Experimental Stress Analysis, John Wiley & Sons, Inc., New York, N. Y., pp. 149–151 (1950).

(**4**) C. C. Perry and H. R. Lissner, "The Strain Gage Primer," McGraw-Hill Book Co., Inc., New York, N. Y., p. 170 (1955).

(**5**) C. J. Newton and H. C. Vacher, "Residual Lattice Strain in Sectioned Bars of Plastically Deformed Iron," *Transactions*, Am. Inst. Metals, Vol. 203, pp. 1193–1194 (1955).

Discussion of Paper on Nitric-Hydrofluoric Acid Evaluation Test for Type 316L Stainless Steel[1]

Mr. C. P. Dillon.[2]—The author is to be commended for undertaking this evaluation of an all-too-pressing subject, namely, quality control of type 316L stainless steel. We would appreciate his comments on the following questions:

1. The data indicate that the electrolytic oxalic acid etch is a good criterion for the quality control of type 316L stainless steel particularly in that a step structure appears to assure resistance to intergranular corrosion. However, the dual structure offers some difficulty. This is contrary to the comments in the Recommended Practice for Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 55 T),[3] which should be revised. We have used the oxalic etch for quality control of type 316L for several years, over the objections of some fabricators who point to the statement in Recommended Practice A 262 to the effect that it should not be used for 316L stainless steel.

2. Our experience has been, however, that "good" type 316 ELC material will fail in the oxalic acid etch if free ferrite is present. We wonder whether this was a factor in the failure of heats HE5, GW6, HR4–3, and EM7. We have tried to determine this by the Schaeffler diagram but without good correlation, possibly due to unreported N_2 contents. Can these heats be examined after poli ' ing and a light oxalic acid etch to determine which actually have free ferrite?

3. Does the author have an explanation for the failure of GC4 (0.028 per cent carbon) and EM6 (0.033 per cent carbon) in both the oxalic acid test and the nitric-hydrofluoric acid test?

4. Does the author have an explanation for the five heats of 0.040 to 0.049 per cent carbon content (HP7, HP3-716, HP6, BZ7-596, and GY5) which pass both tests (although, we note, not a true "step" structure in the etch test)?

5. We have usually "sensitized" type 316L stainless steel for 2 hr at 1250 F, rather than for 1 hr. Is it possible that this longer period would eliminate the failure to screen out the five high-carbon heats?

6. As previously noted, the electrolytic etch appears to be a very good criterion for control of type 316L stainless steel if a step structure is required. Since the additional nitric-hydrofluoric test saves two good type 316L heats from rejection (3 per cent) but rejects two good (?) heats (another 3 per cent) and passes five high-carbon heats is the additional trouble of running

[1] Donald Warren, "Nitric-Hydrofluoric Acid Evaluation Test for Type 316L Stainless Steel," ASTM Bulletin, No. 230, May, 1958, p. 45 (TP 123).

[2] Materials Engineer, Union Carbide Chemicals Co., Charleston, W. Va.

[3] 1955 Book of ASTM Standards, Part 1.

the nitric-hydrofluoric tests worth while? We would be inclined to stay with the oxalic acid test alone. This is particularly true in that we have found corrosion tests like the Strauss test to be ineffective in picking up a high-carbon weld in ELC material, whereas an oxalic acid etch and microscopic examination will—at least in the absence of ferrite (or, actually, massive sigma phase after sensitization).

7. It is interesting to note that of the 80 heats, 2 meet type 317 specifications, 40 meet the type D-319 composition, 33 are true type 316, and 5 meet no standard specification. However, all give less than 0.0010 in. per month in the annealed condition in the Huey test. This seems unusual when the over-all range of composition is:

	PER CENT
Chromium	16.16 to 19.49
Nickel	10.42 to 13.82
Molybdenum	1.89 to 3.03
Carbon	0.017 to 0.060
Manganese	0.71 to 2.16
Silicon	0.15 to 0.88

Would the author have any comments on this observation? These 80 heats of diverse composition would offer an excellent opportunity to run a graphical multiple correlation to determine the effect of individual elements in the type 316 composition as they affect corrosion resistance in a number of environments.

We will be interested in the author's comments, and thank him for a timely and interesting paper.

Mr. DONALD WARREN (*author's closure*). Mr. Dillon's discussion and comments are appreciated. 1. The following reason may be advanced for not using the electrolytic oxalic acid etching test in conjunction with the standard nitric acid test[3] to evaluate type 316L stainless steel. The nitric acid test is sensitive to the presence of finely-divided sigma phase in the grain boundaries of sensitized type 316L stainless steel, whereas the electrolytic oxalic acid etching test is not. Consequently the correlation between the oxalic acid etch structures of sensitized type 316L stainless steel and its nitric acid corrosion rate can be quite poor. That is, sensitized type 316L stainless steel may show a "step" or "dual" structure in the oxalic acid etch test and still fail the nitric acid test.

2. None of the heats "failed" the electrolytic oxalic acid etching test because of the presence of free ferrite in the structure. All of the type 316L heats tested contained less than 0.5 per cent ferrite. Moreover, this ferrite was present as elongated stringers rather than as islands located along the grain boundaries. Consequently, any ditch structure reported in Table VI of the paper was the result of grooving attack (due to carbides) and not the result of pits due to ferrite.

TABLE I.—ELECTROLYTIC OXALIC ACID ETCH STRUCTURES FOR FIVE HEATS OF TYPE 316 STAINLESS STEEL SENSITIZED FOR 2 HR AT 1250 F, WATER QUENCHED.

Heat Number	Carbon Content, per cent[a]	Electrolytic Oxalic Acid Etch Structure[b]		
		Classification	Comments	Encircled Grains, per cent[c]
HP7........	0.040	Dual	Mild dual	...
HP3-716....	0.042	Dual	Mild dual	...
HP6........	0.042	Dual	Mild dual	...
BZ7-596....	0.048	Ditch	Ditch—60 per cent of cross-section Dual—40 per cent of cross-section	60
GY5........	0.049	Ditch	Mostly dual with only three encircled grains	<1

[a] Check carbon analyses made on actual specimens with a Leco carbon conductometric determinator.
[b] Structure obtained by electrolytic etching of sensitized (2 hr at 1250 F, water quenched) specimen in 10 per cent oxalic acid for 1.5 min at 1 amp per sq cm.
[c] Percentage of grains completely encircled by carbide precipitation.

The ferrite present in wrought austenitic stainless steel cannot be determined from the Schaeffler diagram, because this diagram is valid only for cast metal (that is, stainless steel ingots, castings, and weld metal).

3. A maximum carbon content of 0.03 per cent (0.033 per cent) does not guarantee either immunity from carbide precipitation upon sensitization or freedom from the accompanying susceptibility to intergranular attack. For example, Heger and Hamilton[4] have shown that type 304 stainless steel must contain less than 0.028 per cent carbon to have complete immunity to intergranular attack and grain dropping in the nitric acid test (that is, a corrosion rate of 0.0010 in. per month or less). They report nitric acid corrosion rates of 0.0020 to 0.01 in. per month for sensitized type 304 stainless steel containing 0.032 to 0.034 per cent carbon.

In light of the above, the failure of the two type 316L heats GC4 (0.028 per cent carbon) and EM6 (0.033 per cent) is not surprising.

4 and 5. The author has no explanation for the unusual resistance to carbide precipitation of those five heats containing 0.040 to 0.049 per cent carbon (HP3-716, HP6, HP7, BZ7-596, and GY5). The alloy compositions of the heats provided no clue; perhaps their behavior is related to the prior mechanical processing history.

At Mr. Dillon's suggestion, the author sensitized specimens of these five heats 2 hr at 1250 F, water quenched. The oxalic acid etch structures of the sensitized specimens are given in Table I. After the previously reported sensitization of 1 hr at 1250 F, water quenched, all of the five heats showed "dual" oxalic acid etch structures. Increasing the sensitizing time at 1250 F to 2 hr produced no change in the etch structure of the three heats containing 0.040 to 0.042 per cent carbon, but produced a "ditch" structure in the two heats containing the highest carbon (0.048 to 0.049 per cent). However, only heat BZ7-596 contained enough carbide-encircled grains to affect seriously its resistance to intergranular corrosion.

It has been our experience that a sensitizing time of 1 hr at 1250 F is usually sufficient to evaluate the resistance of a stainless steel to carbide precipitation caused by welding.

6. The electrolytic oxalic acid etching test has been shown to be a reliable screening or acceptance test. However, because this test is not an actual corrosion test, the majority of users are not willing to consider it as the sole basis for rejection of stainless steel.

7. Comparative corrosion rates in boiling 65 per cent nitric acid (five 48-hr periods in individual flasks) were available for 46 of the 80 heats[5] of type 316L stainless steel in the annealed condition. Of these 46 heats, 91 per cent had nitric acid corrosion rates within the range of 0.00051 to 0.00090 in. per month; 4.5 per cent had rates between 0.00041 and 0.00050 in. per month; and 4.5 per cent had rates between 0.00091 and 0.00110 in. per month. The two heats having annealed corrosion rates between 0.00091 and 0.00110 in. per month were FI4A and GU3, with chromium contents of 16.2 per cent and 16.8 per cent, respectively. Their higher corrosion rates are probably due to their low chromium contents, because annealed specimens of these heats underwent only general corrosion in the nitric acid test. There was no apparent effect of other compositional variations on the nitric acid corrosion rate for the annealed condition.

[4] J. J. Heger and J. L. Hamilton, "Effect of Minor Constituents on the Intergranular Corrosion of Austenitic Stainless Steels," *Corrosion*, Vol. 11, No. 1, pp. 6t–10t (1955).
[5] The remaining 34 heats had been tested in a multisample tester; and therefore, their annealed corrosion rates were not strictly comparative with the rates for the flask-tested specimens.

A Machine for Evaluation of High-Temperature Alloys Under Combined Static and Dynamic Stresses*

By PAUL E. HAWKES and C. HAROLD EK

A resonance type of testing machine has been developed to serve as an aid in the development of new high-temperature alloys. The machine subjects the specimen to a static or stress-rupture loading combined with a high-frequency fluctuating stress, to simulate service loadings typical of highly stressed components such as gas turbine buckets, wheel materials, combustion chamber liners, and the like. The test temperature range is from 1000 to 1800 F.

The static (axial) component of stress is obtained through the use of a lever and dead weight system, while the dynamic stress results from lateral resonant vibration of the vibrating system composed of the specimen itself together with the axial loading device chucked to its upper end. The machine is equipped with two servo systems for automatic control of amplitude of lateral vibration and of temperature at the test section.

A digital program which calculates the stresses and vibratory elastic line of a 12-section axially loaded beam is employed as a convenience in obtaining a stress calibration for the machine under a variety of combined loadings, materials, and temperature distributions.

Results of tests on two high-temperature alloys, A286 and GMR235D, are included to illustrate the utility of the machine. Data are presented as modified Goodman type diagrams as well as three-dimensional diagrams incorporating axes of static loading, dynamic loading, and time.

During operation of a gas turbine engine, turbine buckets are subjected to a static tensile stress due to centrifugal forces acting on the bucket and flexural fatigue stresses due to resonant vibration of the bucket. Because of these conditions, bucket failure may be due to stress-rupture, fatigue, or a combination of both. For this and other applications a need was felt for an elevated-temperature bench test machine capable of evaluating the simultaneous effects of creep loading and flexural fatigue stresses on small specimens of high-temperature alloys. The requirements of the machine were considered to include the following:

1. Specimens must be small enough to be machined from gas turbine buckets, housing materials, and the like in order to evaluate the original metallurgical structure of the service parts.

2. The frequency of the fluctuating component of stress must be high enough so that in a given period of time (100 hr or less) the number of stress cycles is of the same order of magnitude as that which would be experienced in service over the same period of time by typical lightweight members.

3. The fluctuating component of stress must be flexural in order to simulate what was believed to be the majority of service loadings.

The machine herein described was designed to meet these objectives. Several have been built and employed as an aid in the development of new high-temperature alloys in cooperation with the Metallurgical Engineering Dept. of the Research Staff and Allison Division of General Motors Corp. The bench test machines developed are described and the results of tests of two alloys are discussed briefly.

Machine Description

A view of the base of the machine with the specimen unclamped is shown in Fig. 1. Static tensile loading on the test specimen is obtained by means of a dead weight and lever arm system through which stresses of 85,000 psi have been obtained.

Superimposed dynamic flexural stresses are obtained by employing an electromagnet and regenerative feedback system to vibrate in resonance an elastic system comprised of the specimen and axial loading assembly. The resonant elastic line or deflection curve for the system is shown in Fig. 6.

The frequency range of tests conducted has been from 450 to 650 cps, with a maximum flexural stress of 45,000 psi obtainable under combined stress conditions. (The machine may also be employed to carry out high-tem-

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C. H. EK is a graduate of General Motors Institute, where he received a B.S. degree in Mechanical Engineering. Mr. Ek is presently a Research Engineer at the General Motors Research Laboratories where he has been employed since February, 1954. He has specialized in experimental stress analysis, fatigue testing, and vibration studies.

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perature fatigue studies, without axial loading, at higher stress levels.)

Heating of the specimen is obtained by means of an air-acetylene torch. Suitable servo controls are incorporated into the machine to obtain constant amplitude of vibration and constant temperature over a period of 100 hr or less.

Test Specimen

Specimen dimensions are shown in Fig. 2. Failures of the specimens generally occur $\frac{3}{16}$ in. to the right of the shoulder of the 0.250-in. radius section, which is in the zone of highest stress and temperature.

The specimens are prepared before testing by a standardized procedure involving grinding, followed by chamfering and polishing the test surfaces where maximum stress occurs to remove all grind marks. The polishing operation consists of first using 240-grit paper, followed by No. 600 wet or dry polishing paper and final polish with 000 emery cloth.

Creep Load and Clamping System

The specimen is rigidly clamped between four $\frac{5}{16}$ by $\frac{1}{8}$-in. brass-plated clamps attached to the front and rear clamping blocks. The front clamp block is tightened in place both on the top and through the sides by bolts to hold the specimen rigidly against the brass-plated clamps.

Axial tensile loading is applied by means of a 0.083-in. diameter "torsion straight" music wire connected to a 4:1 lever system. This loading system utilizes the chuck and tapered lock system shown. The specimen is securely clamped in the lower chuck of the system by means of a split nut. The lower portion of the piano wire is brazed into a taper pin which is then brazed into the top of the specimen chuck. The taper pin is cut in the form of a long quarter ellipse to reduce concentration of the bending stresses present in the wire and pin. The top of the piano wire is held in place in a hanger by means of taper locks made of beryllium copper.

The above system then fits onto the lever arm as shown in Fig. 1, by means of which the static tensile stress is applied. In order to prevent misalignment and flexure stresses in the specimen, the whole lever arm system must be held rigidly in position while remaining free to pivot. This is accomplished by clamping a cross-shaft, which acts as the fulcrum of the lever system, tightly in the lever arm. The shaft is in turn carried by two ball bearings secured directly to the frame of the machine. An elevating screw is used to lower or raise the lever arm and independently support the static loading

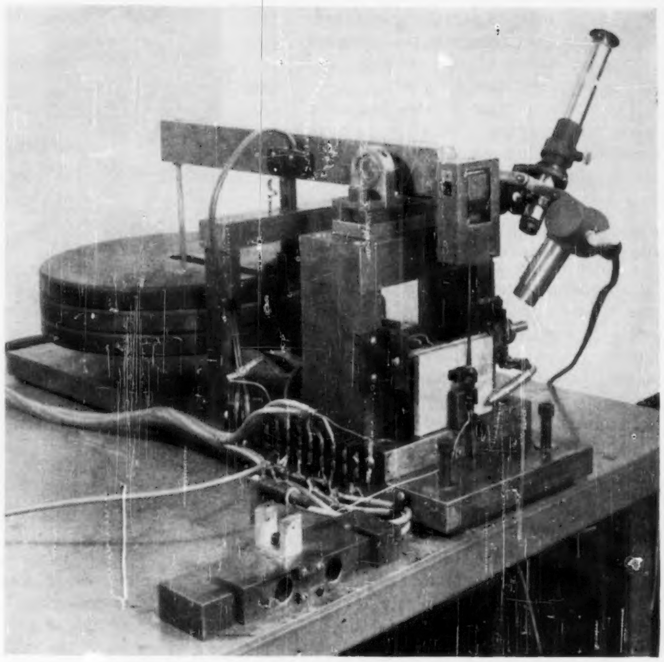

Fig. 1.—Base of high-temperature test machine.

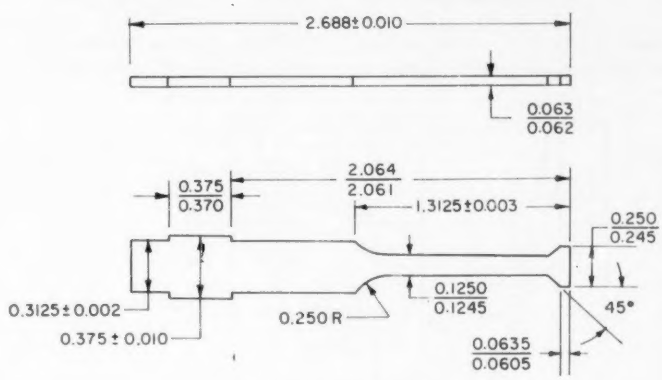

Fig. 2.—Specimen dimensions.

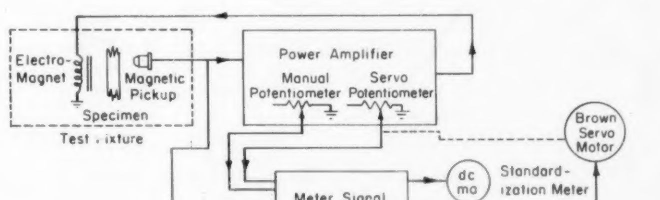

Fig. 3.—Block diagram of amplitude servo control.

weights in order to prevent shock loading and possible damage to the specimen during insertion of the weights and setting up a specimen for test.

The entire system is attached to a heavy base and frame which is, in turn, mounted on silicone rubber disks which act as vibration absorbers.

Vibration Amplitude Control System

Figure 3 is a block diagram of the basic control system developed to regulate accurately the resonant vibratory stress through the course of a test. The system basically employs an electromagnet powered by an amplifier to excite the specimen. The input signal to the amplifier is obtained by means of a magnetic pickup located near the specimen. This signal also serves as the input to the servo system for automatic control to maintain a constant amplitude of vibration. Figure 4, which is a view of the specimen clamped in place and heated, shows the magnetic pickup and a portion of the electromagnet used to vibrate the specimen.

By way of explanation of the block diagram in Fig. 3, vibration of the specimen generates a small a-c voltage in the coils of the magnetic pickup, the value of which is proportional to the amplitude of vibration. This small a-c voltage serves as the input voltage to the power amplifier whose output serves to excite the electromagnet.

The output voltage of the magnetic pickup also serves as the input voltage to the error detector unit. In this unit the small a-c voltage of the pickup is suitably amplified and rectified to provide a d-c signal which is compared with a reference d-c voltage to provide an error signal for servo amplitude control. The amplitude control has proved sufficiently stable to operate with no visible deviation from the set point over a 100-hr test.

The meter signal amplifier merely matches signals on the power amplifier and error detector unit in order that no error signal will be fed into the servo system when switching from manual operation to servo control. Amplitude of

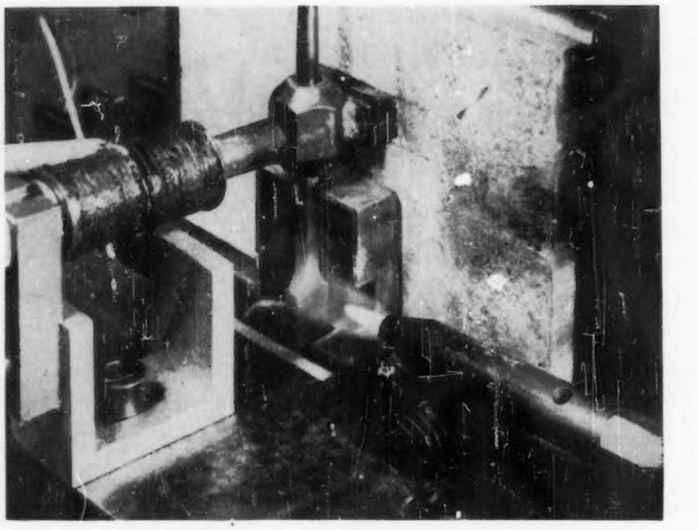

Fig. 4.—View of specimen clamped and heated.

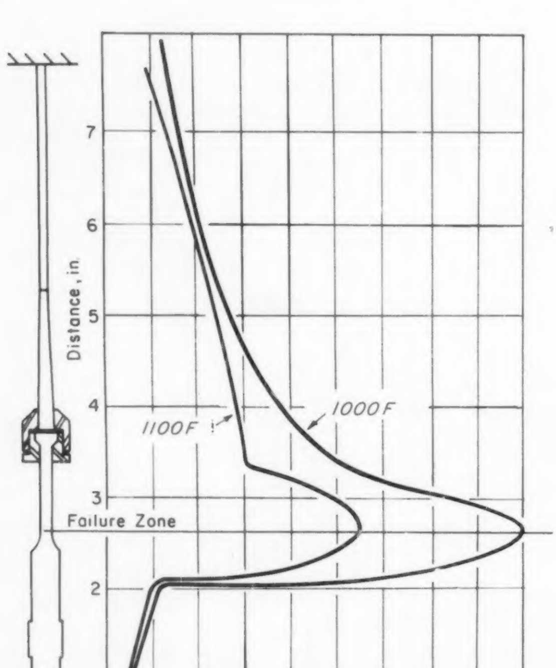

Fig. 5.—Temperature distribution curves of vibrating system.

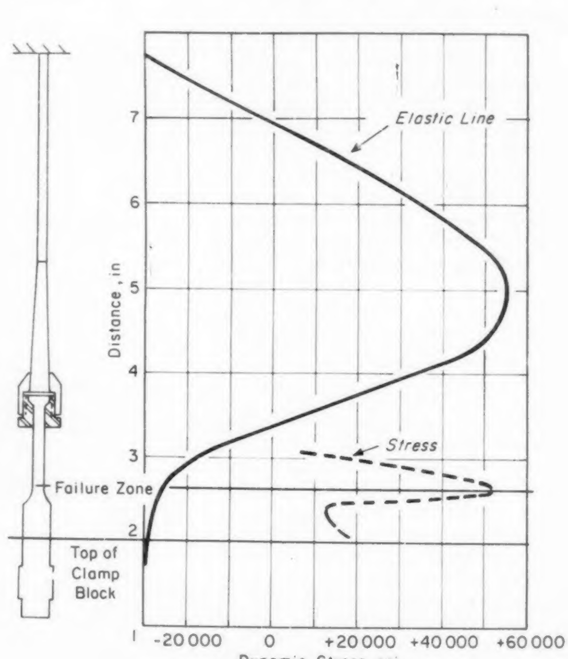

Fig. 6.—Typical elastic line and dynamic stress curve of vibrating system.

vibration is read by observing fiducial highlights on the vibrating system through a calibrated microscope.

Temperature Control System

Heating of the specimen is obtained by means of an atmospheric air-acetylene torch. Temperature is recorded by means of thermocouples welded at the neutral axis in the zone of high stress and failure on the specimen. Temperature distribution curves for tests at 1100 and 1800 F are shown in Fig. 5. Temperature control is obtained by means of a Leeds & Northrup temperature recorder and series 20 control unit operating a Brown 90-deg phase-shift motor to operate a needle valve to control the flow of acetylene. Control within ± 5 F is normally obtained with this unit.

Chromel-alumel 28-gage thermocouple wire is used for the temperature monitoring device at 1100 F. As a result of rapid deterioration of the chromel alumel at 1800 F, Driver-Harris 242-33 alloy was used for testing at this temperature.

The stress calculation for the axial component of load is simply $S = \frac{P}{A}$ since it was established that, with the specimen dimensions used, the stress concentration factor under axial loading was negligible at the plane of failure (**1**).[1]

Dynamic Stress Computation

Because of the complex nature of the problem of computing vibratory stresses in an axially loaded multiple beam of varying section and varying temperature (and therefore modulus) over its length, the computation was carried out on a digital computer.

The necessary equations and computer program for the solution of a 12-section axially loaded beam had previously been set up for determining the natural frequencies, stresses, and mode shapes of tapered gas turbine buckets, and were therefore available for this application (**2**).

Such a program makes it possible to obtain stress calibration quickly for the testing machine for a variety of axial loads, specimen material, moduli of elasticity, and modulus variations due to temperature. Flexural stress at the critical section can then be obtained as a function of vibratory deflection at any conveniently measured point.

The necessary boundary conditions for the calculation, that is, the degree of fixity at the lower end of the specimen and at the upper end of the piano wire tension element, were verified by first running a series of room temperature calculations and comparing predicted natural frequencies, elastic lines, and specimen stresses with values obtained with a calibrated microscope and wire strain gages. Best correlation was obtained when the effective free length of the lowest beam section was assumed to extend $\frac{1}{8}$ in. down into the clamped zone.

A series of curves was then obtained for each type of specimen material showing dynamic *versus* static stress at a constant vibratory amplitude for various temperatures at which tests were contemplated. By reading the deflection of the test specimen at a reference point on the upper end of the chuck through a calibrated microscope, the dynamic stress was then known. A typical dynamic vibratory amplitude curve, together with vibratory stress in the specimen, is shown in Fig. 6.

Test Results

Results of tests on A286 alloy (a commercially available high-temperature alloy manufactured by Allegheny-Ludlum Steel Corp.) at 1100 F and GMR235D (a nickel-base high-temperature alloy developed at General Motors Research Staff) at 1800 F are given to illustrate the utility of the machine. These tests were run at the request of the Allison Division for general design purposes.

Specimens of alloy A286 were machined from the outer perimeter of a forged turbine wheel segment. The segment was solution heat treated and aged before machining the specimens. The specimens were machined in such a direction that the fiber flow lines due to forging would be perpendicular to the direction of principal stresses applied during testing. Specimens of alloy GMR235D were machined from cast Allison J-71 turbine buckets near their leading edges. The buckets were given a treatment of 2 hr at 2100 F in atmospheric air before machining. All specimens were prepared by a standardized process involving grinding, followed by chamfering and polishing the test surfaces where maximum stresses occur to remove all marks due to grinding.

Tests were run at mean tensile stresses

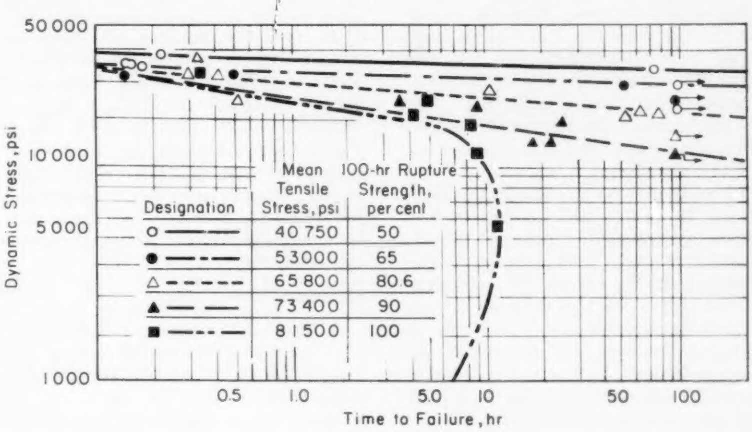

Fig. 7.—Dynamic stress *versus* time to failure of alloy A286 at 1100 F.

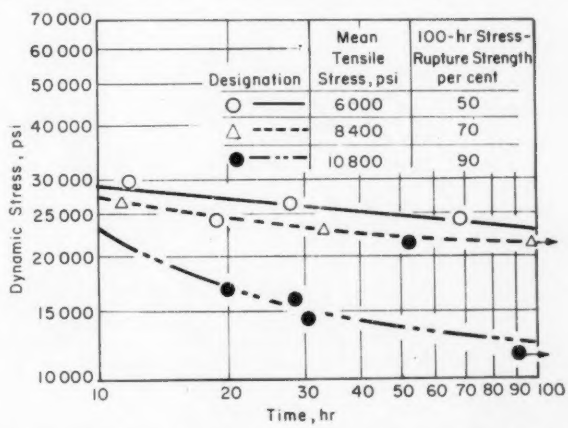

Fig. 8.—Dynamic stress *versus* time to failure of alloy GMR235D at 1800 F.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

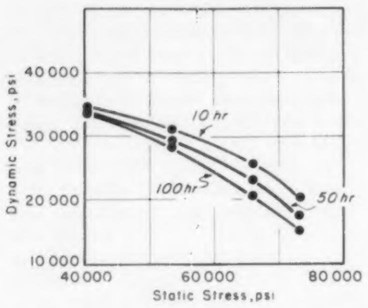

Fig. 9.—Modified Goodman diagram of alloy A286 at 1100 F.

of 50 to 100 per cent of the published 100-hr stress-rupture strength of 81,500 psi at 1100 F for alloy A286 and 50 to 90 per cent of the 100-hr stress-rupture strength of 12,000 psi at 1800 F for alloy GMR235D.

Tests were run by maintaining a constant static stress level (which was some percentage of the 100-hr stress-rupture strength figure) and varying the fatigue stress in successive tests until plots of time to failure *versus* alternating component of stress for each static stress level were obtained to 100 hr. (Although the frequency of vibratory stress varied somewhat at different mean tensile loadings, in Figs. 7 and 8 test results are reduced to a common time-to-failure basis.)

Modified Goodman diagrams (Figs. 9 and 10) of allowable combinations of static and dynamic stresses at 10, 50, and 100 hr were constructed for the materials from the results. Three-dimensional plots as in Figs. 11 and 12 were also constructed on a logarithmic or cartesian basis to give an over-all picture of strength in terms of permissible dynamic stress, static stress, and time, for all temperatures of interest.

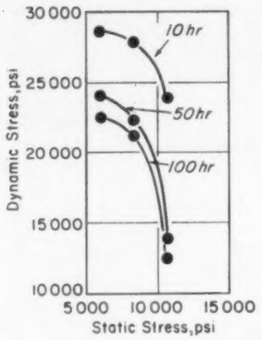

Fig. 10.—Modified Goodman diagram of alloy GMR235D at 1800 F.

NOTE.—These results should be interpreted as scatter bands of approximately 2000 psi in breadth; the exact slopes of the curves have not been fully established.

The 100-hr stress-rupture strength of alloy A286 at 1100 F was found to be slightly below a previously published value of 81,500 psi, probably because of the transverse forging fiber.

The results obtained, together with other available data for both materials, show relatively little loss in permissible dynamic stress component as steady stress is increased to a high fraction of the 100-hr stress-rupture value. At low values of static loading or, in other words, as conventional fatigue testing conditions were approached, the slopes of the *S-N* diagrams were nearly horizontal at the lower temperatures but became greater as the temperature was increased.

Summary

A high-frequency elevated temperature bench test machine has been developed for the evaluation of combined stress-rupture and flexural fatigue stresses. Steady stresses to 85,000 psi together with cyclical flexural stresses to 45,000 psi are obtainable. Frequency is set sufficiently high to provide for the relatively great number of cycles often experienced by blades, panels, and other lightweight engine elements in a given period of exposure. Results of tests of two high-temperature alloys are included for illustration purposes.

Acknowledgment:

The authors would like to acknowledge the support of the Allison Division of General Motors Corp. for much of the work carried out.

References

(1) R. E. Peterson, "Stress Concentration Design Factors," John Wiley & Sons, Inc., New York, N. Y., pp. 66–69 (1953).

(2) John T. Horner, "Numerical Method for Solving Beam and Vibration Problems," General Motors Corp., Allison Division Report (Unpublished).

(3) Albrekt Herzog, "Elevated Temperature Fatigue Testing of Turbine Buckets," Air Force Technical Report No. 5936.

(4) B. J. Lazan and F. Vitovec, "Creep-Rupture and Notch Sensitivity Properties of S-816 Alloy Up to 1650 F Under Fatigue and Static Stress," Symposium on Metallic Materials for Service at Temperatures Above 1600 F, Am. Soc. Testing Mats., pp. 69–89 (1955). (Issued as separate publication *ASTM STP No. 174*.)

Fig. 11.—Three-dimensional stress diagram, alloy A286 at 1100 F.

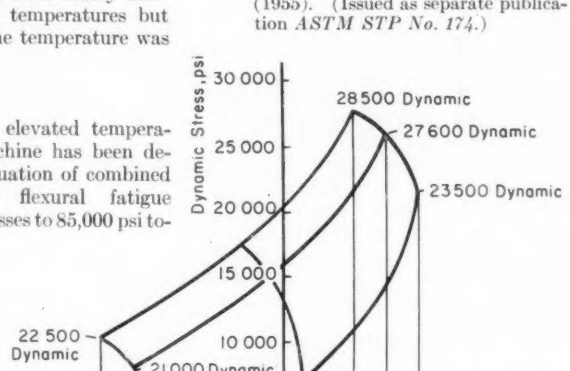

Fig. 12.—Three-dimensional stress diagram, alloy GMR235D at 1800 F.

DISCUSSION

MR. L. S. BIRKS.[1]—When the specimen is tapped and put in vibration at its resonance frequency it is then driven with an amplifier. If the resonant frequency tends to change as the temperature goes up, does the amplifier continue to drive the specimen at the original frequency or at its new resonant frequency?

MR. C. H. EK (*author*).—With the pickup and driving system used, the driving frequency will shift with the resonant frequency of the specimen and loading system. However once the conditions have stabilized there is very little shift in frequency until failure starts to occur.

There is a change in the damping of the system which can be noted; however, the amplitude controller compensates for this. After perhaps a half hour, less power is required to maintain amplitude than was needed at the start of a test.

MR. P. R. TOOLIN.[2]—This interesting paper inspires two questions. First, have the results obtained on this machine been compared to those obtained on older types of machines? Second, has any heating of the specimen critical section due to hysteresis been noted?

MR. EK.—Some of the materials tested have also been studied by other investigators. I believe Mr. Vitovec (**4**) in his paper reported one of the alloys we have also run. Our tests indicated higher allowable fatigue loading for comparable amounts of static loading. Although we are running in the neighborhood of 2,000,000 cycles per hour we found higher resistance to fatigue than Mr. Vitovec found.

We have not investigated this difference in detail, as this test machine was designed to simulate as best we could the conditions encountered by typical high-temperature alloys in service, wherein sections are often relatively thin and are subjected to appreciable flexural component of stress. There is thus a large "size effect" or "stress gradient" effect present which would be expected to result in higher fatigue resistance in our own specimens than in specimens subjected to axial fatigue loading.

We have not noted any significant effect of heating of the specimen due to hysteresis. In this test the temperatures at the point of failure are controlled to maintain a constant value of from 1000 to 1800 F. Any heating due to hysteresis would be only a minute factor which would be corrected by the controller.

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[2] Research Engineer, Mechanics Department, Westinghouse Electric Research Laboratories, Pittsburgh, Pa.

[3] F. Vitovec, "Effect of Static Prestrain on the Fatigue Properties," *Proceedings*, Am. Soc. Testing Mats., Vol. 58, (1958).

Measurement of Bulk Modulus of Hydraulic Fluids

BY R. L. PEELER AND J. GREEN

Definitions of bulk modulus and published measurements on potential hydraulic fluids are reviewed. An ultrasonic velocity apparatus for determining adiabatic bulk modulus at temperatures to 500 F and pressures to 5000 psi is described. Measurements are reported on MIL-H-5606A fluid (petroleum-base) and Oronite high-temperature hydraulic fluids 8515 and 8200 (silicate ester-base). Only minor differences were found among the three fluids, with the silicate ester fluids having slightly higher bulk moduli above 400 F. Isothermal bulk modulus was calculated from the adiabatic value and was found to approach the latter as the temperature increased.

BULK modulus (reciprocal of compressibility) of the hydraulic fluid is one of the critical design parameters affecting the performance of hydraulic servomechanisms. The demands of high-speed aircraft for hydraulic systems operating at higher temperatures have led to the use, or serious consideration, of new types of fluids. This paper covers a survey of the published literature and describes equipment and presents data for ultrasonic velocity measurements on three hydraulic fluids for aircraft.

Bulk modulus measurements at both high temperatures and high pressures have been made only infrequently. The ultrasonic velocity method allows accurate measurement of adiabatic bulk modulus with a mechanically simple apparatus. The bulk moduli of three aviation hydraulic fluids were measured from room temperature to 500 F and from atmospheric pressure to 5000 psi. The fluids tested were a MIL-H-5606A fluid (petroleum-base, polymethacrylate viscosity index improver, oxidation inhibitor, and tricresyl phosphate), Oronite high-temperature hydraulic

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

fluids 8200 (disiloxane base, silicone viscosity index improver, oxidation inhibitors), and 8515 (8200 fluid plus aliphatic diester).

Definition of Bulk Modulus

Two definitions are commonly used for bulk modulus:

$$B = -V\left(\frac{\partial P}{\partial V}\right) \quad \text{.........(1)}$$

$$\bar{B} = V_0\left(\frac{P - P_0}{V_0 - V}\right) \quad \text{......(2)}$$

where:

B = bulk modulus,
$\bar{B}$ = "mean" bulk modulus,
P = pressure,
V = volume,
P_0 = reference pressure, usually atmospheric, and
V_0 = volume at P_0.

Equation 1 is the thermodynamic definition of bulk modulus. It is related to the other thermodynamic properties of the fluid through a series of well-known equations (**1**).[1] This is the "tangent" modulus of ASTM Definition E 6 - 54 T.[2]

Equation 2 defines a "mean" bulk modulus for which P_0 is almost invariably chosen as atmospheric pressure. It represents the "secant" modulus of ASTM Definition E 6 - 54 T. Either bulk modulus can be determined under isothermal or adiabatic conditions, the condition being indicated by the subscripts T or S, respectively.

Literature Survey on Bulk Modulus Measurements

The accessible published literature was reviewed for bulk modulus measurements or data from which bulk modulus could be derived. A list of high-boiling organic and inorganic liquids for which these measurements are available is given in Table I.

Although measurements have been made on many high-boiling liquids, in about half the cases these data have not been converted by the authors to bulk modulus (or compressibility) values. Two types of measurement account for all the values: pressure-volume-temperature (P-V-T) and ultrasonic velocity measurements. The former method is mostly used under isothermal conditions, giving B_T or $\bar{B}_T$, but has infrequently been used under adiabatic conditions (**13,46,47,48**). The ultrasonic velocity method yields B_s for a liquid directly

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Tentative Definitions of Terms Relating to Methods of Mechanical Testing (E 6 – 54 T), 1955 Book of ASTM Standards, Part 1, p. 1547; Part 2, p. 1201; Part 3, p. 1963; Part 4, p. 1341; Part 6, p. 1682; Part 7, p. 1617.

TABLE I.—BULK MODULUS MEASUREMENTS ON POTENTIAL HYDRAULIC FLUIDS.

Fluid	Temperature, deg Fahr	Pressure psi, max	Method Used	Bulk Modulus[a] Reported	Reference
Petroleum Base					
36 Lubricants	32 to 425	150 000	P-V-T[b]	...	(2)
1 Lubricant and 5 fuel oils	68 to 257	17 060	P-V-T	$\bar{B}_T$	(3)
5 Lubricants	104	22 400	P-V-T	B_T	(4)
2 Hydraulic fluids	−40 to 160	50 000	P-V-T	...	(5)
MIL-O-5606 fluid	68	3 500	P-V-T, c[c]	$\bar{B}_T$, B_s	(6)
MIL-O-5606 fluid	−100 to 500	10 000	Review	$\bar{B}_T$	(7)
11 Lubricant fractions	104 to 167	56 900	P-V-T	...	(8)
6 Lubricants	77 to 167	56 900	P-V-T	...	(9)
5 Petroleum fractions	57 to 210	6 000	c	...	(10)
6 Lubricants and 8 fuels	32 to 572	711	P-V-T	B_T	(11)
9 Fuels	68 to 104	7 110	c	B_s	(12)
Diesel fuel	32 to 210	6 000	P-V-T	B_T, B_s	(13)
Transformer oil	32 to 104	Atmos	c	...	(14)
2 Jet fuels	77	Atmos	c	B_T, B_s	(15, 16)
5 Lubricants	Room temperature	Atmos	c	...	(17)
4 Lubricants	Room temperature	Atmos	c	B_s	(18)
2 Lubricants	Room temperature	Atmos	c	...	(19)
Esters					
Octyl phthalate and sebacate	32 to 425	150 000	P-V-T	...	(2)
Butyl phthalate, methyl oleate, tricaproin	32 to 203	170 000	P-V-T	...	(20)
Octyl phthalate	32 to 104	Atmos	c	...	(14)
Pentaerythritol butyrate	32 to 149	Atmos	c	B_s	(21)
Silicones					
1 Dimethyl and 1 methylphenyl	32 to 425	150 000	P-V-T	...	(2)
15 Dimethyl and 1 methylphenyl	77	569 000	P-V-T	...	(22)
2 Dimethyl	76 to 300	10 000	P-V-T	B_T	(23)
14 Dimethyl and 2 methylphenyl	86 to 123	Atmos	c	B_T, B_s	(24)
3 Dimethyl and 2 methylphenyl	32 to 104	Atmos	c	...	(14)
Halogenated Liquids					
Fluorolube and C_7F_{16}	77	569 000	P-V-T	...	(22)
19 C_2F_3Cl Polymers and 4 perhalocarbons	68 to 140	Atmos	c	...	(25)
Fluorolube FS and triperfluorobutylamine	32 to 149	Atmos	c	B_s	(21)
7 Perfluoro compounds and 2 aroclors	32 to 104	Atmos	c	...	(14)
Aroclor	86 to 158	Atmos	c	...	(26)
Phosphates					
Tricresyl phosphate	32 to 203	170 000	P-V-T	...	(20)
Tricresyl phosphate	32 to 104	Atmos	c	...	(14)
Liquid Metals					
12 Metals	to 896	Atmos	c	B_s, B_T	(27, 28)
Mercury	86 to 572	5 140	P-V-T	$\bar{B}_T$	(29)
Mercury	32 to 158	Atmos	c	...	(30)
Mercury	32 to 302	170 000	Review	B_s, $\bar{B}_T$	(31)
Sodium	208 to 522	Atmos	c	B_s, B_T	(32)
Molten Salts					
14 Salts	MP to 1832	Atmos	c	B_s, B_T	(33)
5 Salts	MP to 1850	Atmos	c	...	(34)
Natural Oils					
Castor, rape, lard, sperm	104	22 400	P-V-T	B_T	(4)
Peanut	68 to 176	17 060	P-V-T	$\bar{B}_T$	(3)
Castor, olive, linseed	37 to 99	Atmos	c	...	(35)
Sperm	Room temperature	Atmos	c	...	(17)
7 Vegetable oils	Room temperature	Atmos	c	...	(36)
Castor	32 to 149	Atmos	c	B_s	(21)
Water	23 to 176	176 300	Review	$\bar{B}_T$	(37)
	10 to 264	136 700	c	...	(38)
	86 to 122	88 200	c	...	(39)
	32 to 86	28 400	c	...	(40)
	32 to 212	Atmos	c	...	(41)
Polymers					
3 Polybutenes	32 to 425	150 000	P-V-T	...	(2)
4 Polybutenes	32 to 140	Atmos	c	...	(42)
Polybutene and polyethylene glycol	...	Atmos	c	...	(43)
5 Polyethylene glycols	86	Atmos	c	...	(44)
50 HB 100	32 to 104	Atmos	c	...	(14)
Miscellaneous					
Glycerin	32 to 203	170 000	P-V-T	...	(20)
Glycerin	32 to 104	Atmos	c	...	(14)
Naphthalene	222 to 884	5 800	P-V-T	...	(45)
5 Synthetic hydrocarbons	32 to 425	150 000	P-V-T	...	(2)
Tetra(2-ethylhexyl)silicate, pydraul F-9	32 to 104	Atmos	c	...	(14)

[a] Or its reciprocal, compressibility.
[b] Pressure-volume-temperature measurements.
[c] Sonic velocity measurements.

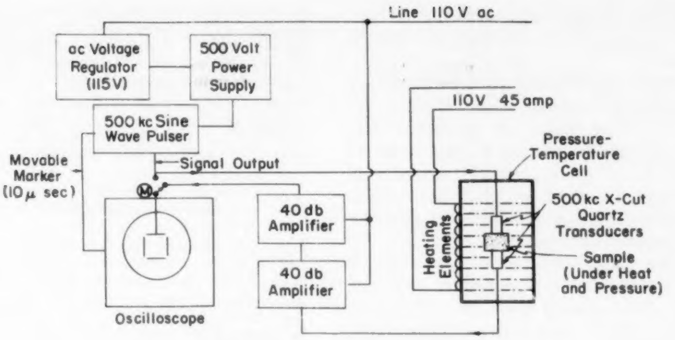

Fig. 1.—Schematic drawing of velocity apparatus.

through the equation:

$$B_s = \rho c^2 \ldots\ldots\ldots\ldots (3)$$

where:

ρ = density, and
c = velocity of sound.

This is a more accurate method than the P-V-T measurements, as the bulk modulus is directly dependent on the quantities being measured rather than on their derivatives.

The isothermal and adiabatic bulk moduli are related through the expression:

$$\frac{B_s}{B_T} = \gamma \ldots\ldots\ldots\ldots (4)$$

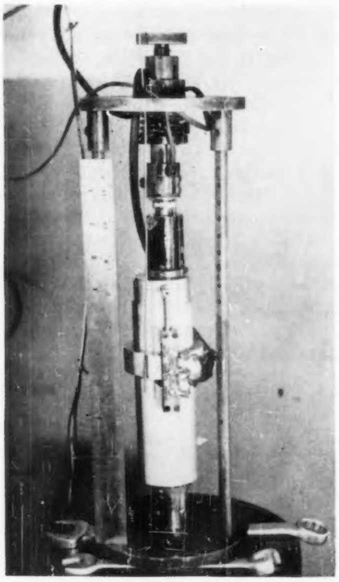

Fig. 2.—Fluid container and transducer assembly.

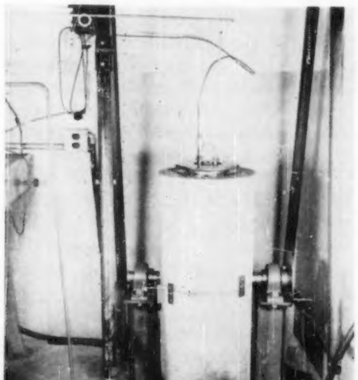

Fig. 3.—Assembled pressure cell.

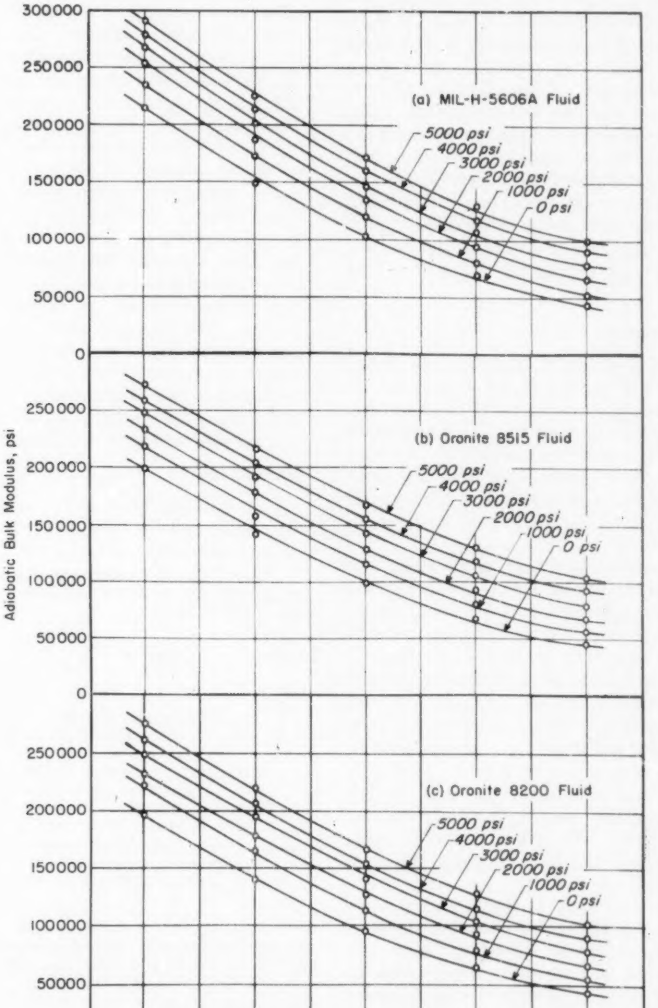

Fig. 4.—Adiabatic bulk modulus of MIL-H-5606A, Oronite 8515, and Oronite 8200 fluids.

where:

$\gamma = \frac{C_p}{C_v}$, the ratio of specific heats.

Cameron (**49**) has reviewed data available on the values of γ for petroleum oils and found them to be from 1.12 to 1.28 near room temperature. Kretschmar (**16**) obtained values of 1.11 to 1.19 for jet fuels at 77 F, Weissler (**24**) of 1.18 to 1.31 for silicones, Kleppa (**28**) of 1.08 to 1.25 for liquid metals at their melting points, Bett *et al* (**31**) of 1.14 to 1.19 for mercury from 32 to 302 F, Pochapsky (**32**) of 1.13 to 1.17 for sodium from 208 to 522 F, and Bockris and Richards (**33**) of 1.11 to 1.56 for molten salts.

Although ultrasonic velocity measurements have often been used for measurements at high temperatures (**27,28,32,33, 34**) or at high pressures (**10,12,38,39,40, 50,51,52,53**), the combination of both is infrequent. Vigoreaux (**54**) has reviewed methods of measuring ultrasonic velocities of liquids, describing the interferometer, optical diffraction, and pulse methods. The latter, with its advantage of mechanical simplicity, appears most suitable for use at high temperatures and pressures and was used in the experimental work reported herein.

Equipment

Adiabatic bulk modulus was determined at the La Habra Laboratory of California Research Corp. in an apparatus which allowed the measurement of density and ultrasonic velocity of a fluid from 75 to 500 F and pressures from atmospheric to 5000 psig. A schematic diagram of this equipment is shown in Fig. 1.

The fluid is placed in an aluminum container closed by a freely moving piston connected to a Bourns Laboratories' model 113 linear potentiometer. This assembly is shown in Fig. 2. Pressure is applied to the fluid by placing the assembly inside a pressure cell and pressurizing with an inert liquid, Dow Corning 550 fluid. An external view of the cell is given in Fig. 3. It is 3 ft long with 5-in. inside diameter and has a removable head with O-ring seals at each end. The cell is heated by strip heaters on the outer surface of the pressure cell.

As the fluid is compressed by the applied pressure, the piston of the fluid container moves, changing the resistance of the linear potentiometer to which it is attached. By appropriate calibration, both the ultrasonic path length and the density of the fluid can be obtained. In practice, a 3-in. long container was used in the ultrasonic velocity measurements and a $5\frac{7}{8}$-in. container for the density measurements to improve accuracy of each type of measurement.

Ultrasonic velocity is determined by measuring the time required for a 100 microsecond pulse of dominant frequency 500-kc per sec to pass between two *X*-cut quartz crystal transducers through the fluid sample. The instrumentation is a modification of that described by Lazarus (**55**).

The time base for all the velocity measurements is established by the calibrated time delay circuit of a Dumont 256-D oscilloscope. The technique for measuring velocity is as follows: A pulse is generated by the oscilloscope at a controlled time during the oscilloscope sweep. This pulse triggers the damped sine-wave pulser. The output of the pulser is amplified and drives an *X*-cut quartz crystal transducer. The ultrasonic wave thus produced passes through the fluid and generates an electrical signal in the output quartz transducer. These output signals are amplified by two Hewlitt Packard 450A amplifiers in series and displayed on the oscilloscope.

The measuring technique consists of superimposing the beginning of the output pulse on a given timing marker and then changing the trigger delay time until the beginning of the input pulse coincides with the same timing marker. The delay time between these two pulses is determined from the setting of the calibrated delay dial on the oscilloscope. A sodium chloride crystal with a known velocity of 15,640 ft per sec (**55**) was used for calibration.

Corrections

In calculating fluid density and ultrasonic velocity from these data, the following corrections were applied:

1. The thermal expansion of the aluminum container is corrected for through use of the formula

$$\rho = \rho_0 \frac{1}{(1 + \alpha\Delta T)^2} \times \frac{1}{1 - \Delta L_0/L_0} \quad \ldots (5)$$

where:

ρ = true density of fluid,
ρ_0 = density of fluid at room temperature,
α = linear coefficient of thermal expansion of aluminum,
ΔT = temperature increase above room temperature,
L_0 = length of potentiometer arm at room temperature, and
ΔL_0 = change in length of potentiometer arm.

2. An additional correction is made for the thermal expansion of the aluminum piston head and cylinder base, which increases the path length through the metal. The increased delay time caused by the expansion of the aluminum is subtracted from the total delay time to give the fluid delay time. This correction is 0.06 μsec at its greatest.

3. A marked hysteresis effect was found for the heating and cooling portions of the density-temperature curves. Comparison with pycnometer data at atmospheric pressure showed the cooling portion of the curve to be accurate. It was therefore used in all density determinations. The apparent error in the heating portion of the curve may be due to thermal lag between thermocouple and fluid sample or to frictional resistance of the piston.

As there are no adiabatic bulk modulus data available on organic fluids over the temperature and pressure range used here, accuracy of the present data could not be determined through use of a reference fluid. From consideration of the individual values used in computing the final result, the accuracy is estimated to be within 5 per cent of the true value.

Experimental Results

The compressibility properties of the three fluids, MIL-H-5606A and Oronite 8515 and 8200 fluids, were determined from 100 to 500 F and from atmospheric pressure to 5000 psig. Density, ultrasonic velocity, and the adiabatic bulk modulus calculated from them using Eq. 3, are given in Tables II to IV. Bulk modulus values are also plotted in Fig. 4. Bulk modulus decreases rapidly as the temperature increases.

The isothermal bulk modulus is related to the adiabatic through several other thermodynamic properties of the fluid (**56**). The form of the equation simplest for calculation from the data obtained above is:

$$B_T = \frac{1}{\frac{1}{B_s} + \frac{T\left(\frac{\partial\rho}{\partial T}\right)^2}{\rho^2 C_p}} \quad \ldots\ldots (6)$$

where:

T = absolute temperature, and
C_p = specific heat at constant pressure.

Specific heat of all three fluids has been measured at atmospheric pressure in this laboratory (**57**), while $\partial\rho/\partial T$ can be obtained graphically from a plot of the density-pressure relationship. Values of these quantities are shown in Table V. A comparison of isothermal and adiabatic bulk moduli is given in Fig. 5. For all three fluids, γ decreases as the temperature increases, that is, B_T approaches B_s.

The effect of pressure on γ can be estimated indirectly. The change in C_p with pressure is given (**1**) by the equation:

$$\left(\frac{\partial C_p}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P \quad \ldots\ldots (7)$$

Evaluation of this quantity for all three fluids shows that C_p is affected less than 2 per cent by a 5000 psi pressure change. Calculation of B_T and γ for several temperatures for each fluid from Eqs 6 and 4, respectively, show γ at 5000 psig to be within 0.02

unit of the value at atmospheric pressure. This small change may reflect experimental error rather than a real difference. Therefore, an approximate value of B_T can be calculated for any pressure to 5000 psig from the values of γ in Table V and of B_s in Tables II to IV without further recourse to Eq. 6.

Summary and Conclusions

An ultrasonic apparatus for adiabatic bulk modulus measurements of liquids is described. It was used successfully for measurements at temperatures to 500 F and pressures to 5000 psi. Accuracy is estimated to be within 5 per cent of the true value. Fluids studied were one petroleum-base and two silicate ester-base aircraft hydraulic fluids. Only minor differences were found between their bulk modulus properties with the silicate ester fluids having slightly higher values above 400 F. The authors conclude that the ultrasonic method is satisfactory for adiabatic bulk modulus measurements at elevated temperatures and pressures.

Acknowledgments:

The authors wish to acknowledge their indebtedness to their colleagues at California Research Corp. for their assistance. Special mention should be made of A. E. Stoddard and H. Brandt.

TABLE II.—ADIABATIC BULK MODULUS OF MIL-H-5606A FLUID.

Pressure, psig	Temperature, deg Fahr	Density, g per cu cm	Ultrasonic Velocity, ft per sec	Adiabatic Bulk Modulus, psi
	100	0.841	4360	215 × 10³
	200	0.801	3720	149
0....	300	0.762	3165	103
	400	0.725	2645	68.3
	500	0.695	2160	43.7
	100	0.839	4565	235
	200	0.808	3990	173
1000....	300	0.770	3395	120
	400	0.736	2845	80.3
	500	0.714	2330	52.2
	100	0.853	4700	254
	200	0.814	4130	187
2000....	300	0.778	3575	134
	400	0.744	3055	93.6
	500	0.724	2610	66.5
	100	0.858	4815	268
	200	0.819	4280	202
3000....	300	0.783	3720	146
	400	0.753	3245	107
	500	0.732	2810	77.9
	100	0.860	4910	279
	200	0.824	4390	214
4000....	300	0.790	3875	160
	400	0.761	3400	118
	500	0.740	2990	89.6
	100	0.864	5000	291
	200	0.829	4500	226
5000....	300	0.796	4000	172
	400	0.767	3550	130
	500	0.749	3150	100

TABLE III.—ADIABATIC BULK MODULUS OF ORONITE 8515 FLUID.

Pressure, psig	Temperature, deg Fahr	Density, g per cu cm	Ultrasonic Velocity, ft per sec	Adiabatic Bulk Modulus, psi
	100	0.914	4020	199 × 10³
	200	0.870	3480	142
0....	300	0.828	2980	99.1
	400	0.788	2530	68.0
	500	0.762	2120	46.1
	100	0.918	4210	219
	200	0.876	3730	157
1000....	300	0.836	3210	116
	400	0.802	2730	80.5
	500	0.778	2330	56.9
	100	0.921	4340	234
	200	0.882	3880	179
2000....	300	0.844	3370	129
	400	0.812	2920	93.3
	500	0.791	2520	67.7
	100	0.926	4460	248
	200	0.888	4010	192
3000....	300	0.852	3530	143
	400	0.821	3100	106
	500	0.800	2730	80.3
	100	0.930	4550	259
	200	0.893	4130	205
4000....	300	0.858	3670	156
	400	0.828	3260	119
	500	0.807	2940	94.0
	100	0.934	4660	273
	200	0.899	4230	217
5000....	300	0.869	3790	168
	400	0.835	3410	131
	500	0.812	3090	105

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TABLE IV.—ADIABATIC BULK MODULUS OF ORONITE 8200 FLUID.

Pressure, psig	Temperature, deg Fahr	Density, g per cu cm	Ultrasonic Velocity, ft per sec	Adiabatic Bulk Modulus, psi
0....	100	0.915	3990	196×10^3
	200	0.866	3460	140
	300	0.821	2930	95.0
	400	0.786	2460	64.1
	500	0.764	2060	43.7
1000....	100	0.920	4230	222
	200	0.874	3740	165
	300	0.832	3180	113
	400	0.798	2710	79.0
	500	0.774	2320	56.1
2000....	100	0.916	4330	231
	200	0.882	3870	178
	300	0.842	3350	127
	400	0.818	2900	92.7
	500	0.786	2510	66.7
3000....	100	0.930	4450	248
	200	0.889	4030	195
	300	0.850	3510	141
	400	0.818	3070	104
	500	0.796	2720	79.4
4000....	100	0.935	4550	261
	200	0.895	4140	207
	300	0.857	3650	154
	400	0.826	3220	115
	500	0.806	2900	91.3
5000....	100	0.939	4660	275
	200	0.900	4260	220
	300	0.864	3790	167
	400	0.834	3390	129
	500	0.814	3060	103

TABLE V.—ISOTHERMAL BULK MODULUS OF HYDRAULIC FLUIDS AT ATMOSPHERIC PRESSURE.

	Temperature, deg Fahr	$\left(\frac{\partial\rho}{\partial T}\right)_p$, g / cu cm deg Fahr	Specific Heat at Constant Pressure, C_p, cal per g deg Cent	Isothermal Bulk Modulus, psi	Ratio of Bulk Moduli $\gamma = B_s/B_T$
8515 Fluid..............	100	0.000435	0.453	168×10^3	1.19
	200	0.000425	0.506	123	1.15
	300	0.000414	0.561	88.5	1.12
	400	0.000337	0.615	63.9	1.06
8200 Fluid..............	100	0.000486	0.395	157	1.25
	200	0.000461	0.453	117	1.19
	300	0.000412	0.530	84.5	1.12
	400	0.000300	0.623	61.1	1.05
MIL-H-5606A Fluid.....	100	0.000413	0.446	175	1.23
	200	0.000398	0.469	125	1.19
	300	0.000386	0.492	89.9	1.14
	400	0.000349	0.515	61.6	1.11

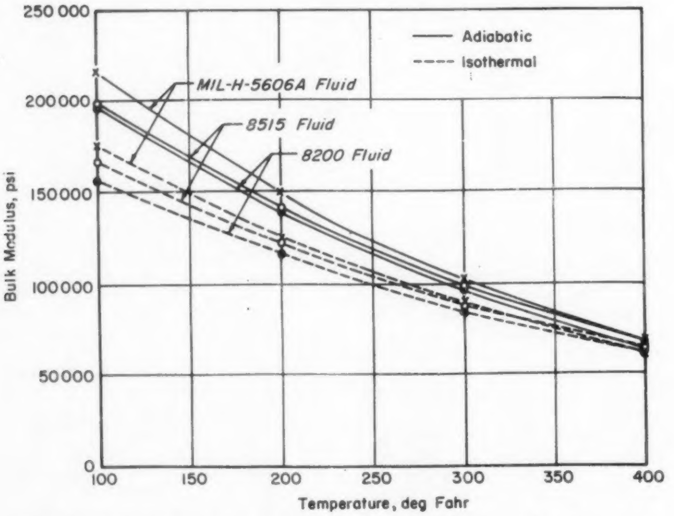

Fig. 5.—Adiabatic and isothermal bulk modulus at atmospheric pressure.

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Accelerated Aging Tests and Life Aging Properties of Aircraft Metal Adhesives[1]

BY J. P. THOMAS

TESTING of adhesives for use in aircraft structural applications is a relatively new field of endeavor. Although adhesives for metal-to-metal bonding in aircraft applications have been in popular use for over a decade, adhesives that can be used for actual high-temperature structural applications have been developed only in the past three or four years. Convair Division of General Dynamics Corporation has been a pioneer in the use of metal-to-metal adhesives for both structural and non-structural applications in aircraft manufacture[2] and accordingly has developed test methods, prepared procurement specifications, and has kept abreast with the current military specifications[3,4] for testing these adhesives.

As greater demands are constantly being made on the aircraft industry for higher performance planes and missiles, adhesive manufacturers and the aircraft industry are involved in developing new and higher-temperature-resistant adhesives. These adhesives must not only appear to be good in sample lots, but must maintain their consistency and reliability from one lot to another so as not to jeopardize the structural integrity of an airplane. As a consequence, a number of tests have been set up in military specifications for testing and evaluating these adhesives. Since there are numerous applications for aircraft adhesives, no one specification can cover all aspects; therefore, some special tests are designed to select specific adhesives for specific applications. Convair has devised several tests, and selected others from military specifications, which give good indications of longevity of a structural adhesive in a specific environment. These specially chosen accelerated aging tests include creep tests, vibration fatigue, salt spray, fluid immersion, and two sandwich panel structural tests, namely the "Iron Maiden" and "box beam" tests. These two tests are borderline between structural and accelerated aging tests. They have been included because even with all the information supplied by smaller tests, such tests as these are needed to confirm the over-all test results and establish design limits. In addition, another group of tests considered of particular importance at Convair which gives an indication of the life-aging properties of an adhesive includes long-time fuel immersion and sandwich panel weathering tests. Since the following tests entail specimens of the sandwich panel type or lap shear type, Fig. 1 shows typical examples of these types of specimens. It will be noted that the sandwich specimen half section has two skins adhesive-bonded to honeycomb core, with a slug bonded at the end. The lap shear specimen consists of two adhesive-bonded overlapped skins. In both cases, the specimens are bonded at elevated temperatures and pressures up to 175 psi.

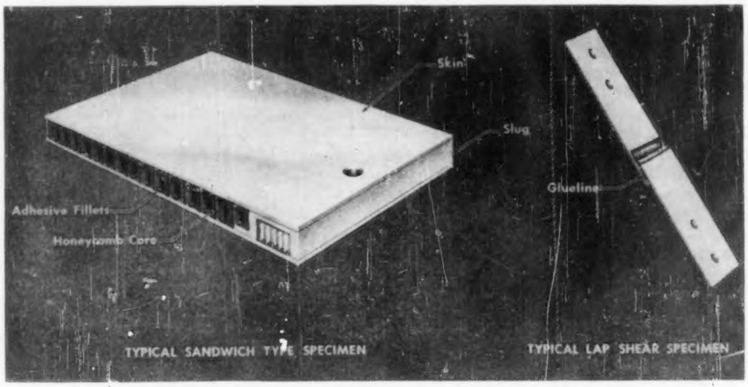

Fig. 1.—Sandwich and metal-to-metal bonded specimens.

Accelerated Aging Tests

Creep and Structural Tests

The first group of tests to be discussed are "accelerated aging" tests, which include column creep-accelerated beam, metal-to-metal creep rupture, vibration fatigue, the "Iron Maiden," and box beam tests.

The first test is the accelerated column-creep and beam test. This

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[2] D. A. Tooley, "How Adhesives Are Used in Aircraft Construction," *Materials and Methods*, Vol. 39–40, pp. 105–107 (Feb., 1954).

[3] MIL-A-5090B Adhesive; Airframe Structural, Metal to Metal, July 1, 1954.

[4] MIL-A-8431 Adhesives, Heat Resistant, Airframe Structural, Metal to Metal, March 2, 1955.

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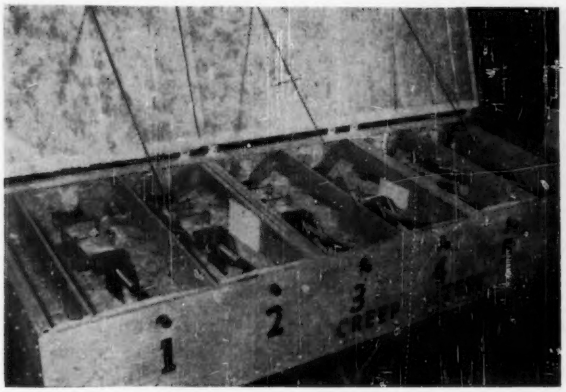

Fig. 2.—Accelerated column-creep and beam test.

Fig. 3.—Accelerated column-creep and beam test showing specimen stirrups.

test was devised as a means of quickly screening a large number of sandwich specimens fabricated with various adhesives and processes. By comparing the data obtained, an adhesive having the best over-all characteristics for sandwich construction may be selected. The test is a means whereby axial load and beam load can be applied simultaneously at an elevated temperature. In Fig. 2, the insulated box with its relation to the axial loading and beam loading devices may be seen, as well as a portion of the load lever system for load application. Figure 3 shows a close-up of the load blocks with ball joints and the stirrups for beam-load application. The procedure consists of properly milling the 3.5 by 15.0 by 0.5-in. specimen so that the slug will extend 0.1 in. beyond the skins. A scribe line is made across the glueline of the slug and skins on one side to measure the creep. The specimen is then placed in position as shown in Fig. 2, computed axial load and beam loads applied to give the desired stress, and the temperature brought up to 260 F. Six dial gages, measuring in thousandths of an inch, are employed to measure beam deflection, and an optical micrometer is used to measure total deformation or creep at the slug. Each specimen position for axial load application must be calibrated because of the 50 to 1 advantage of the compound lever system for applying axial load. From calibration curves, the proper weight to be placed on a hanger for a desired loading condition is determined. Since temperature is critical, each specimen is equipped with a thermocouple to ensure that the desired temperature will be maintained. The beam and axial loads are increased every 3 hr so that design limits will be reached in 12 hr. The loads are then increased on a 3-hr schedule until failure occurs. A typical frequency failure distribution

Load	Beam, lb	Axial, lb	Failures, per cent
A	163	2300	None
B	188	2800	11
C	248	3300	68
D	323	4300	21

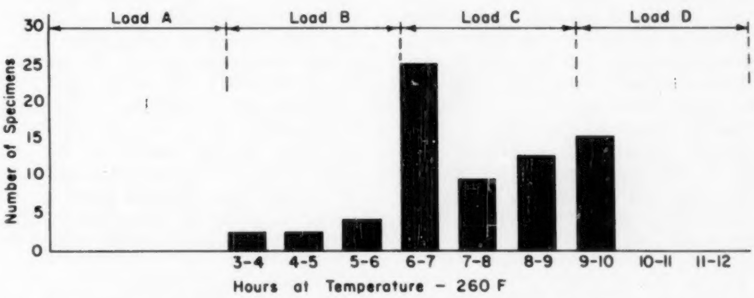

Fig. 4.—Frequency failure distribution in 64 column-creep specimens 3.5 by 15-in. transverse ribbon glass fiber core with 0.90-in. aluminum alloy skins without slags; layer vinyl-phenolic adhesive.

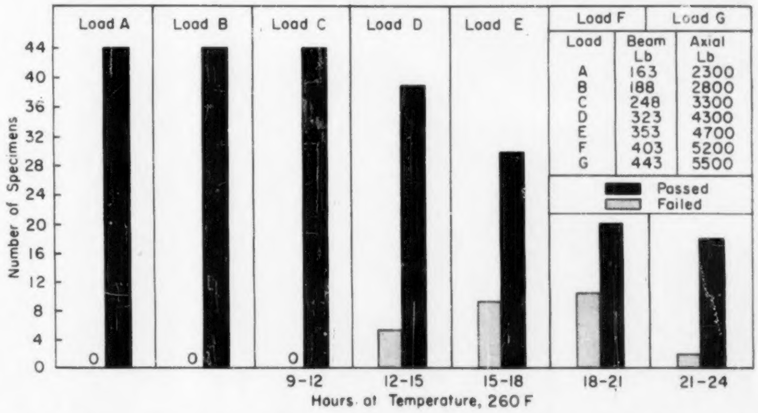

Fig. 5.—Frequency failure distribution in 44 specimens 3.5 by 15-in. longitudinal ribbon glass fiber core with 0.40 in. aluminum alloy skins; epoxy-phenolic adhesive.

chart is shown in Fig. 4. The loading schedule gives the several increments of design load to be applied. The ordinate of the chart represents the total number of specimens run and the abscissa shows the time intervals with design limits at 12 hr. It will be noted that at the completion of the C load, 79 per cent of the vinyl-phenolic adhesive bonded specimens had failed. In comparison, Fig. 5 shows specimens bonded with an epoxy-phenolic adhesive, which (unlike the vinyl-phenolic) is a high-temperature adhesive and exhibits 43 per cent unfailed even after the G load. These data are valuable mainly from a comparison basis.

Closely associated with the column creep-accelerated beam test is metal-to-metal creep rupture. Whereas the former dealt with sandwich-type specimens, this test employs metal-to-metal lap shear specimens. Essentially, the test is designed to determine the tendency of an adhesive to creep or to distort under static loads at elevated temperatures. This is one of the tests that appears in the military specifications and is a familiar test to those who are acquainted with adhesive testing. A new method for applying static loads for creep tests has been developed at Convair, as shown in Fig. 6. This consists of a small pneumatic ram which—in conjunction with an air regulator and proper air supply—will maintain the desired load on a ½-sq in. lap shear bond.

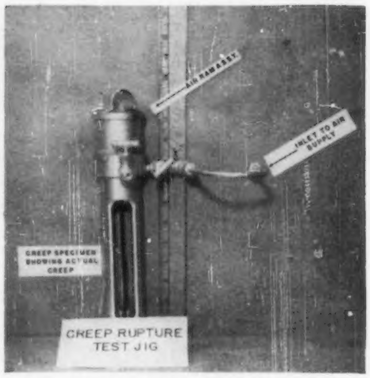

Fig. 6.—Creep rupture test jig.

Regular lap shear specimens, 1 in. wide and 7 in. long, are prepared by jig-drilling holes in both ends and milling one side to clearly expose the glueline. Scribe lines are then made on this milled section of the overlap joint to aid in creep measurement by an optical micrometer. An axial load of 1200 psi is applied to the specimens, and they are then heated to test temperature. Creep is measured at 4, 8, 16, and 24 hr and each 24 hr thereafter until 200 hr has elapsed. A section of the glueline, showing actual creep in a lap shear specimen, is also shown in Fig. 6. In practice, a number of specimens may be run simultaneously in a minimum of space; consequently, this jig has proved quite useful. A creep test jig which will allow 18 specimens to be tested simultaneously, equipped with a micrometer device for taking creep measurements without going into the oven, is now in the proof-testing stage—employing the basic unit shown in Fig. 6.

Another test considered of importance as an accelerated aging test is the vibration fatigue test. Fatigue data are important in determining design parameters for an adhesive and are attained by applying axial load through cyclic means to a specimen of similar dimensions to those of the lap shear creep specimens just described. One of the several types of vibration fatigue machines used is shown in Fig. 7. The specimen is placed in the machine and a cyclic axial load of 600 psi, not exceeding 3600 cpm, is applied for 10 million cycles or until failure. This property of fatigue is strongly considered in selecting adhesives for aircraft construction.

Two accelerated aging tests found very helpful in determining the structural integrity of adhesives used in sandwich panels are the "Iron Maiden" and box beam tests. The "Iron Maiden" test was developed to determine design limits (heat, pressure, and load) for sandwich construction and to evaluate design changes on new adhesive development under various conditions.

As may be observed in Fig. 8, the "Iron Maiden" is a large steel frame designed to give horizontal support to a panel being tested in compression. It

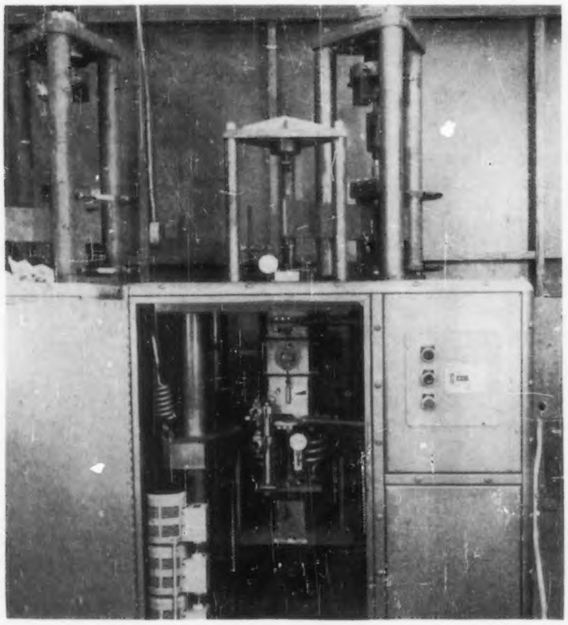

Fig. 7.—Vibration fatigue machine.

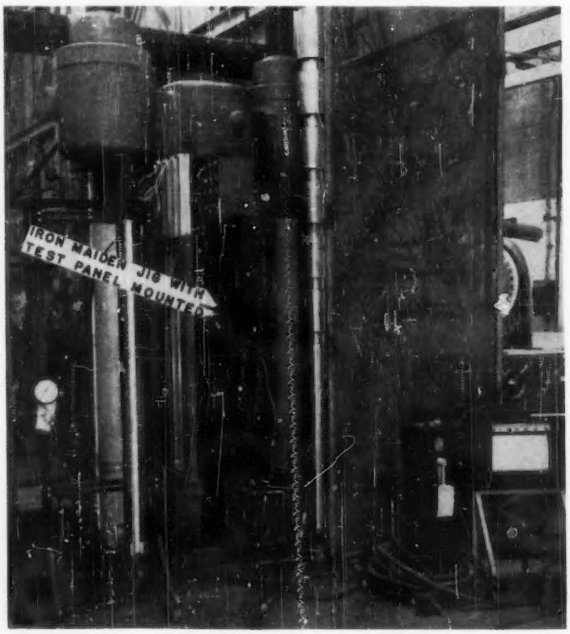

Fig. 8.—Iron maiden test setup.

is designed to permit application of air pressure to one surface of the panel and heat to the opposite side. The panel is attached to the frame by roller bolts to allow vertical load only to the panel.

The failure stress of each panel is compared to failure stresses of similar panels run under the same conditions. Test temperatures range from −68 to +500 F, and internal pressure ranges from 0 to 40 psi. Individual panels may be tested with temperature differentials ranging from 0 to 300 F between the two surfaces of the panel.

In order to insure efficient detail wing design of sandwich construction, it was necessary to determine the interaction of stresses due to combined loading for typical wing-surface sandwich panels under environmental conditions, through accelerated means. Thus, the box beam test was developed, which would simulate as closely as possible actual interaction of stresses and combined loading applied to a panel in flight and at subsonic and supersonic speeds. Figure 9 depicts a typical setup for this type test. Each box beam consists of two sandwich-type wing panels with slugs and honeycomb core. Two steel bulkheads (see *A*, Fig. 9) (with load introduction fittings on each end of each bulkhead) have attached to them three spans, 50 in. long (see *B*, Fig. 9). The outboard or end spans each terminate in a beam system (see *C*, Fig. 9) which allows all torsion to be reacted by the center test section (see *D*, Fig. 9). At the same time the beam system reacts the bending loads through non-moment-introducing end straps (see *E*, Fig. 9) to the base platform. The panels are bolted integrally to the aluminum spars and overlap the bulkheads to introduce bending load. By proper manipulation of the hydraulic ram loads, the center test section can be made to undergo pure bending, pure torsion, or a combination of the two. The panels are tested both at 260 and minus 68 F. Some box beam splice test interaction curves may be observed in Fig. 10. The ordinate represents bending stress *versus* shear stress in the abscissa. Seven specimens were tested in pure bending stress and eleven in combination loads of bending stress to shear stress. The most typical ratio for obtaining design allowables is with a bending stress to shear stress of 10:3. From these tests, a typical curve was established which set the lower limits for structural sandwich panel construction.

Weathering and Age Tests

The salt-spray test is a special accelerated corrosion and weathering test in which specimens are exposed at a temperature of 95 F to a fine mist of

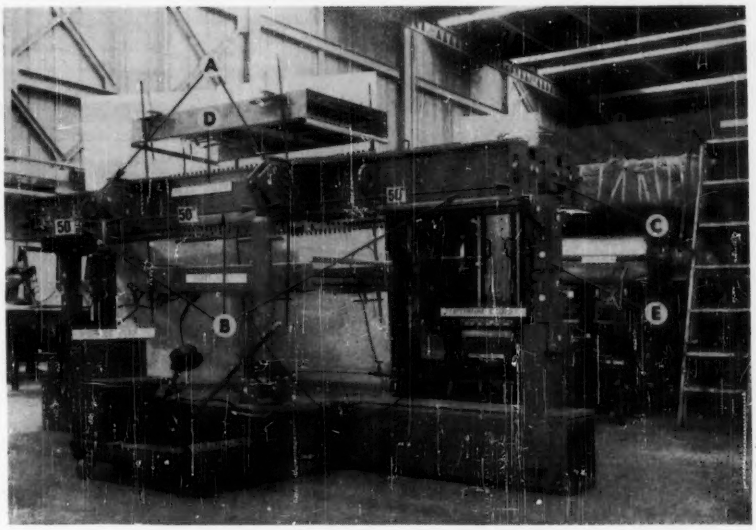

Fig. 9.—Typical box beam wing panel test setup.

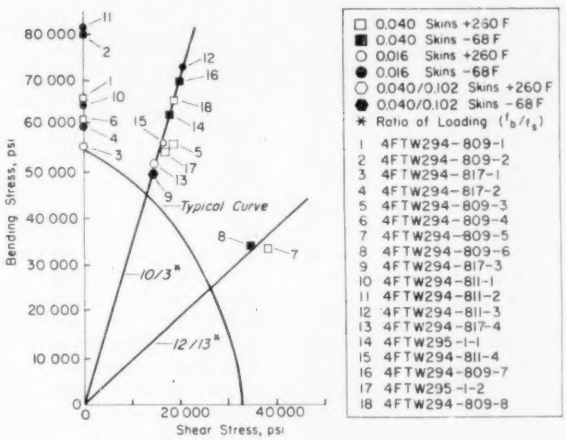

Fig. 10.—Box beam splice test interaction curves.

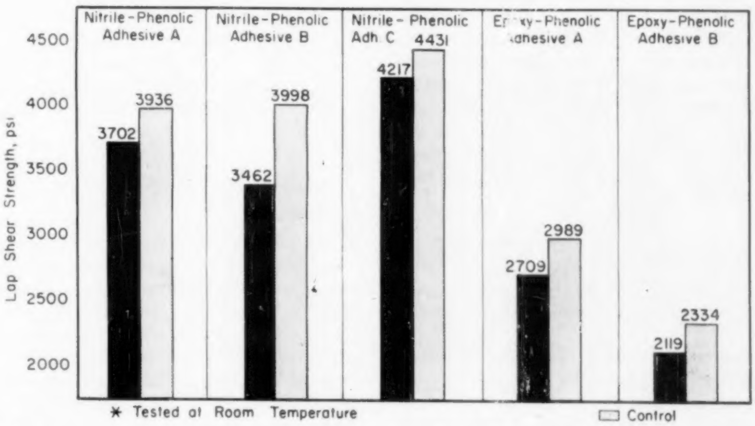

Fig. 11.—Typical salt spray data for several adhesives bonded on 2124T-3 alclad aluminum (½-in. Lap Joints).

5 or 20 per cent sodium chloride solution. It is useful in establishing and maintaining certain standards of quality and is particularly indicative as to how an adhesive might hold up under marine conditions.

Those who are familiar with adhesive or corrosion testing are acquainted with the details of this test, as called for in Federal Test Method Standard No. 151,[5] paragraph 4.6 of MIL-E-5272A[6], and ASTM Method B 117–49 T.[7] The specimens are placed in a non-conducting holder at a 15-deg angle in a salt-spray cabinet and subjected to salt spray for 30 days. Data for several adhesives after 30-day exposure to salt spray are shown in Fig. 11. It might be of interest to point out that lap shear specimens, tested before and after salt spray exposure, show that the nitrile-phenolic and epoxy-phenolic adhesives are affected only slightly by this exposure when compared with unconditioned control specimens.

Fluid-immersion tests are conducted primarily to determine the effect of various fluids on adhesive bonds when the fluid is in close contact with the glueline. Most of the fluid-immersion tests performed to date have been accomplished by using the standard methods in MIL-A-5090B.[3] Standard 9 by 7½-in. lap shear pads are bonded with the test adhesive. One-inch wide control specimens are cut from either end. The controls are then tested in lap shear at 77 ± 2 F. The remaining portion of the pad is immersed in various fluids and allowed to remain there 30 days in tap water or 7 days in any one of the following: hydraulic fluid (MIL-O-5606),[8] hydrocarbon fluid type III (MIL-H-3136),[9] or anti-icing fluid (MIL-F-5566).[10] Following the immersion, the pads are removed from the various fluids, sawed into 1-in. wide specimens, and tested in shear within a 2-hr period. Results of fluid immersion tests on two nitrile-phenolic adhesives are shown in Fig. 12. It appears that for both adhesives, immersion has some effect on the adhesives. Immersion in any of the four fluids did not, however, bring the adhesives below design limits or the minimum shear strength stipulated in the military specification.

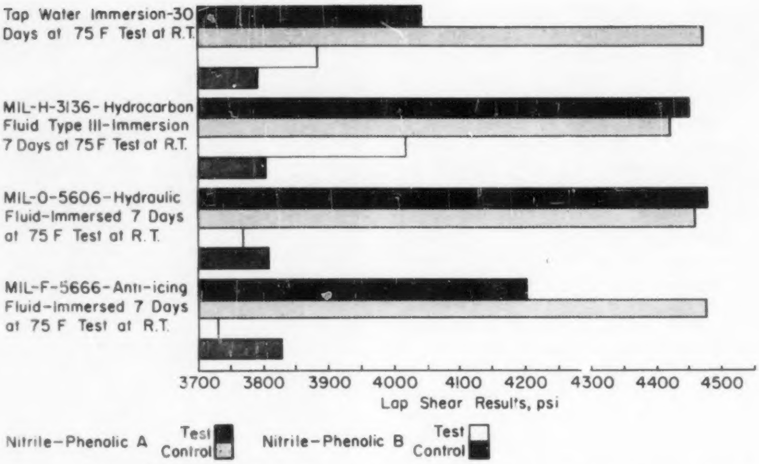

Fig. 12.—Lap shear tests after immersion in various fluids. Specimens bonded on 2024 T-3 aluminum (½ in. lap joints), nitrile-phenolic adhesives A and B.

Life Aging Properties

A group of tests sometimes called life aging properties tests, are considered of special importance when dealing with metal or sandwich-type adhesives. Tests included in this group are long-time fuel immersion and sandwich panel weather aging tests.

First, we will consider long-time fuel immersion tests. Some adhesives come into direct contact with fuel. For this reason, it is deemed necessary to know the effects of long-time fuel immersion on structural adhesives. Continuous fuel immersion tests have been in progress for several years at Convair on lap-shear type specimens. Any degradation is noted as specimens are periodically removed and tested in shear. The procedure for immersion of these specimens in JP-4 jet fuel is the same as described previously under fluid immersion, with the exception that the JP-4 is maintained at 140 F. The specimens are removed periodically and tested in shear at 77 ± 2 F and 260 F. Typical data, shown graphically in Fig. 13, are the results of long-time fuel immersion on a nitrile-phenolic and an epoxy-phenolic adhesive. No appreciable degradation has occurred on these adhesives after one year of immersion. The slight variation indicated might well be due to test variables. Continuation of these tests have demonstrated no significant degradation of these two adhesives even after 3 years of fuel immersion.

Sandwich panels fabricated with adhesives are used in fuel tank areas of certain aircraft. Since it is possible that fuel may possibly find its way to the adhesive and remain there for long

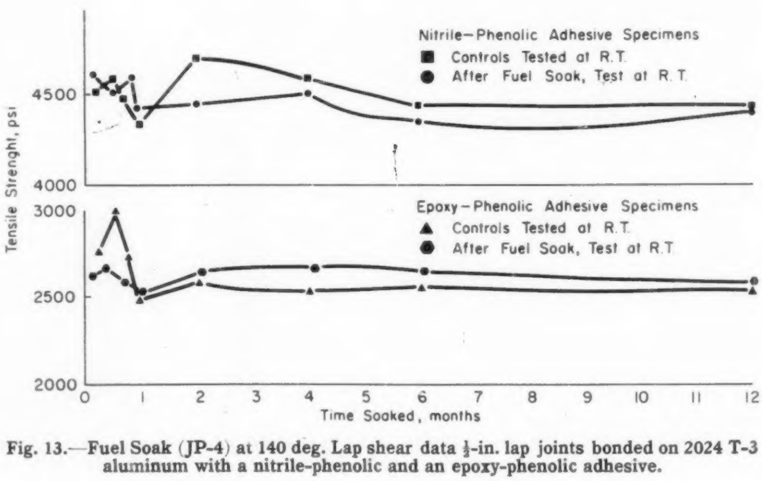

Fig. 13.—Fuel Soak (JP-4) at 140 deg. Lap shear data ½-in. lap joints bonded on 2024 T-3 aluminum with a nitrile-phenolic and an epoxy-phenolic adhesive.

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[5] Federal Test Method Standard 151 Metals; General Specification for Inspection of.

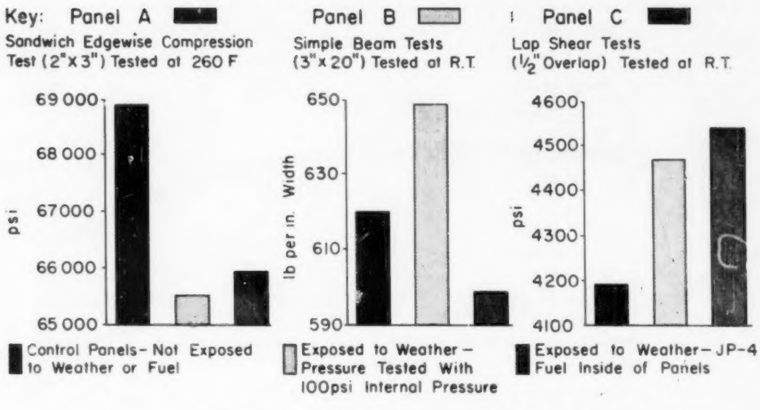
[6] MIL-E-5272A Environmental Testing, Aeronautical and Associated Equipment, General Specification for, Sept. 16, 1952.

[7] Tentative Method of Salt Spray (Fog) Testing (B 117–49 T), 1952 Book of ASTM Standards, Part 2.

[8] MIL-O-5606 Oil; Hydraulic, Aircraft, Petroleum Base.

[9] MIL-H-3136 Hydrocarbon-Fluid, Standard Test.

[10] MIL-F-5566 Fluid; Anti-Icing (isopropyl alcohol).



Note: Panels B & C Were exposed to Weather for One Year.

Fig. 14.—Typical data from weather aging test. Honeycomb sandwich panel, glass fiber core, 0.040-in. aluminum skins, epoxy-phenolic and nitrile-phenolic adhesives.

periods of time, it was considered imperative that the effects of such an environmental condition be determined. Therefore, a test was initiated in which sandwich panels were purposely filled with JP-4 fuel and exposed to outdoor conditions. The panels are standard-type sandwich panels with slugs and glass-fiber-reinforced honeycomb core, and are filled with JP-4 before being subjected to weather. Typical data from lap shear, simple beam, and column compression tests, where the specimens were cut from the test panel, appear in Fig. 14. Specimens from panel *A* served as controls and were unaged, while specimens from panel *B* were exposed to weather and pressure-tested to 100 psi internal pressure. Specimens from panel *C* were exposed to weather with JP-4 jet fuel inside. The edgewise compression results appear in psi; simple beam, in lb per in. width; and lap shear, in psi. These tests were conducted after one year of weathering, and are being continued.

Summary

Some of the more important accelerated aging tests and life aging properties tests of metal adhesives, based on engineering experience at Convair, have been described. Due to rapid advances in the state of the art in the aircraft adhesive field, new test methods must constantly be devised to keep pace with the new applications found for these adhesives.

The tests that have been described are examples of test methods which are believed to give reliable data that can be used to predict the performance and longevity of aircraft metal adhesives in actual service.

Acknowledgment:

These tests were conducted in the Engineering Test Laboratory at Convair-Fort Worth.

The assistance of H. P. Owen from the Chemical Section who directed some of these tests, and of H. D. Nolan and W. F. Heidbrier who performed the "box beam" tests, and W. L. Wallace who conducted the "Iron Maiden" tests is gratefully acknowledged.

Resin-glass Bond Characteristics

By F. J. McGARRY

Three methods have been developed to measure the mechanical strength of the joint between cast resins and single glass elements. One of these utilizes electrical grade glass rods of 0.010-in. diam. The methods give consistent results and indicate that various chemical finishes on the glass surface have no significant effect on the bond strength. The methods also quantitatively demonstrate the importance of friction effects between glass and resin in laminate behavior. Further, it has been found that the bond characteristics of epoxy and polyester resins differ greatly; the latter joins to glass much more weakly and when fractured, does so in an entirely different fashion compared to the epoxy-glass fracture, breaking cleanly at the polyester-glass interface at shear stress values much below the shear strength of either the resin or the glass. This suggests either a strength deterioration of the glass surface or local contamination and improper cure of polyester resin.

In the mechanical performance of fibrous glass-resin composites, the strength of the joint between the two components, irrespective of its precise physical or chemical character, is thought to be of critical importance. Externally applied loads are transmitted to and between the primary structural elements, the glass fibers, through these joints or bonds and if they should be broken, mechanical strength and stiffness and chemical and moisture resistance would seriously deteriorate. Much work, largely of a necessarily empirical nature, has been directed toward improving the performance of fibrous glass-resin composites by concentrating on this region of the structure. Greatest attention has been devoted to various chemical treatments of the glass surface, the so-called finishes, with complex organic-inorganic molecules reputed to link chemically with one end to the glass and with the other to the resin as the later polymerizes (**1**).[1] Much progress has resulted by utilizing this concept despite the absence of any proof of its validity, but such progress has

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

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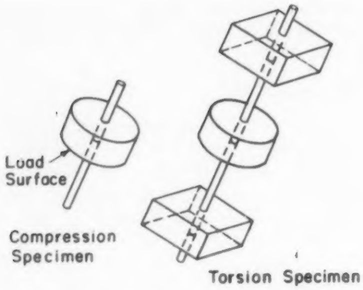

Fig. 1.—Compression and torsion rod-disk specimens.

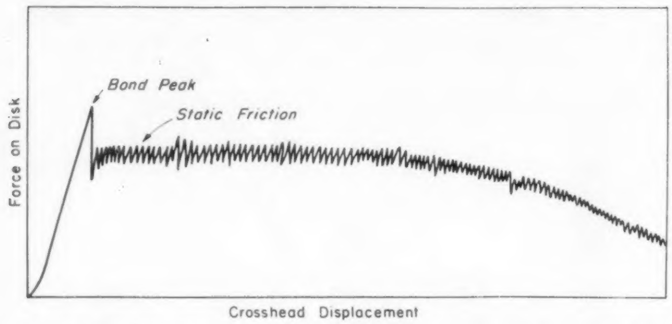

Fig. 2.—Force-displacement record from typical compression test on rod-disk specimen.

been of a qualified nature not widely recognized:

1. The improvements in laminate properties from such finishes have been manifest primarily in terms of "wet-strength retention" where strength and stiffness retention after water immersion for perhaps 30 days at 72 F is greatly improved by certain finish treatments. For example, one of the earliest finishes, a methacrylato-chromic chloride designated as finish 114 enabled a laminate to retain 60 per cent of its dry flexural strength after such immersion; recent organo-silicones have raised this figure to 95 to 100 per cent (**2**). No comparable improvement in dry strengths has occurred however; indeed the modest increases in dry strengths which have been realized may well be due to other effects, the most likely ones being a general improvement in the art of laminating and slightly better controls over the many variables in the process.

2. Most of the development work on glass surface treatments or finishes has utilized laminates as the experimental media, where literally millions of individual glass fibers are distributed as woven fabrics, nonwoven mats, or continuous filament rovings with a degree of complexity hardly amenable to either precise analysis or control. Further, in the preparation of such laminates a great deal of art is present in terms of placement of the glass, distribution and penetration of the liquid resin, avoidance or removal of entrapped air, heating and cooling rates during the curing or polymerization process, methods and duration of pressure applications, catalysis of the reaction, etc. Some of these have been shown to be very effective in terms of final laminate properties; others are so difficult to control positively that their effects are still not well understood.

For reasons implicit in the preceding, it was judged a desirable goal to devise methods of directly measuring the mechanical strength of the joint between a resin matrix and a single glass element. Thus far, three procedures have been developed, two of which involve glass rods of a few millimeters in diameter while the third has utilized a thin rod of 0.010 in. diam. Experience to date with the latter leads to the belief that it can be successfully applied to glass filaments as commercially drawn: 0.0003 to 0.0005 in. diam, thus fulfilling one of the initial purposes of the research.

[2] Manufactured by the Rohm & Haas Co., Philadelphia, Pa.

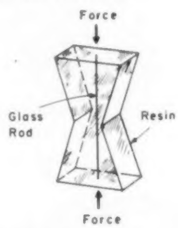

Fig. 3.—Trapezoid compression specimen for use with small diameter glass rods or filaments.

Experimental Procedure

The first approach involved glass-rod resin-disk specimens as shown in Fig. 1. These were prepared by casting a commercially available polyester resin, Paraplex P-43,[2] in Teflon cups with a 1-in. internal bore around Pyrex rods obtained from chemical stock and then curing the resin by a combination of catalysis with benzoyl peroxide and mild heating (150 F) in an air oven with no applied pressure. This technique permitted controlled variations in rod diameter, glass surface treatment, and disk thickness and provided a specimen suitable for either compression testing, wherein the disk was pushed along the rod, or torsion testing in which the disk was twisted around the rod with no displacement along the rod axis. Both such tests were performed on a hydraulic testing machine operating at a displacement rate held constant, and the automatically recorded force-deformation traces are of the character shown in Fig. 2. At the end of the initial, reversible, linear behavior fracture between the rod and disk takes place and then a stick-slip action, accompanied by an audible clicking, sets in with the load variations indicated. This is characteristic of a dry frictional action and reveals that a normal pressure between the rod and disk remains after fracture, this pressure being large enough to make the static friction load level from 70 to 95 per cent of the maximum or fracture load in the test. Only after the disk has been displaced along the rod for an appreciable distance, compared to its thickness, does the average friction load start to decline; in a torsion test perhaps one complete revolution of the disk occurs before the same diminution commences.

The third method uses a trapezoid of the shape indicated in Fig. 3, where a thin rod or filament of electrical grade E glass is surrounded by a casting of resin, the cross-section of which varies along the length of the rod. By compressing the specimen, a nonuniform shear stress is created between the glass and resin which reaches a maximum at the minimum cross-section of the piece; the magnitude and variation of this stress is dependent upon the dimensions of the specimen and the glass rod and the elastic moduli of the two materials. When fracture occurs at the neck of the back-lighted specimen it can be readily detected by the onset of a fuzzy white line caused by the optical action of the fractured surface. Knowing the load at which this takes place permits a calculation of the shear strength of the joint between the resin and glass rod. To date, experiments have been conducted with rods of electrical grade E glass material of 0.020 and 0.010 in. diam. In the near future smaller sizes will be used until, eventually, commercially drawn fibers of 0.0003 to 0.0005 in. diam will be tested.

Test Results

In the rod-disk compression tests, variables included rod diameter, disk thickness, and glass surface treatment. The results of the initial tests with

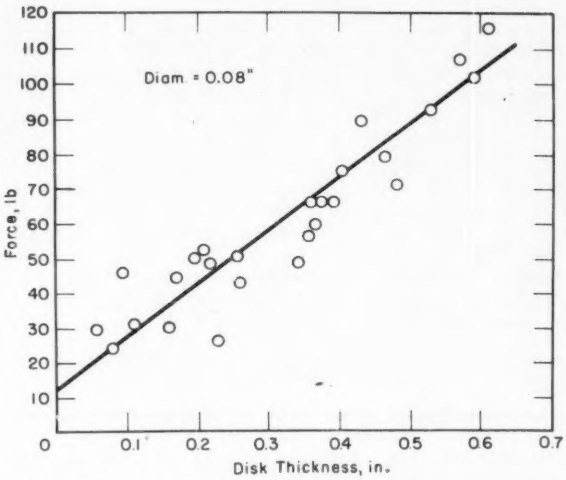

Fig. 4.—Bond-strength disk-thickness relationship for acetone-washed Pyrex rods of 0.08-in. diam. Slope corresponds to bond stress of 614 psi. Meniscus constant, 12 lbs.

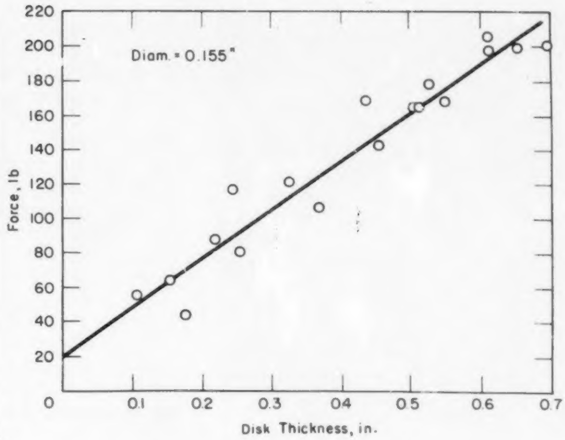

Fig. 5.—Bond-strength disk-thickness relationship for acetone-washed Pyrex rods of 0.155-in. diam. Bond stress 590 psi. Meniscus constant, 21 lb.

Pyrex rods and Paraplex P-43 resin are presented in Figs. 4, 5, and 6. In the tests shown in Figs. 4 and 5, the glass rods were washed in acetone prior to having the disks cast around them; those in Fig. 6 were cleaned with acetone (plain glass) or treated with a vinyl silane solution known as Finish 136 (finished glass). The average bond strength in Fig. 4 is 614 psi while that in Fig. 5 is 590 psi, but because of the scatter in results this difference is not considered significant. An interesting point from the two illustrations is the meniscus constants of 12 and 21 lb caused by the fact that the disk thickness measurement was an average not attempting to take into account the dimensions of the meniscus. Ideally these values should differ by a factor of 2, because of the ratio of rod diameters.

In Fig. 6, the bond strengths are 605 psi for the acetone-washed, plain glass and 680 psi for the finish 136 treated glass. Again because of the scatter in results this difference is of questionable validity, and subsequent work shows it to be not real. One fact from Fig. 6 is significant however: the meniscus constants differ appreciably because the meniscus on the finished glass was much higher, dimensionally, than that on the plain glass. This difference in glass surface-wetting characteristics was readily evident upon visual inspection and is borne out by the data in Fig. 6. It is felt that the data illustrates the true mechanism by which glass finishing agents have been found effective in upgrading practical laminate behavior, as will be subsequently discussed.

Numerous reservations about the absolute validity of the compression tests on the rod and disk specimens led to the development of torsion tests on the same systems. Though much more difficult to perform experimentally, the torsion tests provided almost no scatter in results and made certain the conclusion that glass finishes do not effect bond strength in a direct fashion. This is demonstrated, for example, by Fig. 7 in which the average bond strength is 963 psi, and a well-defined meniscus constant of 10 lb is established. In addition, numerous tests of the Finish 136 showed that it had no effect on the torsion test results. Finally, the lack of scatter in the torsion tests suggests that it is the better way in which to determine the joint strength of such systems though experimental convenience motivated a return to compression testing, keeping in mind the ultimate goal of very small diameter glass rods.

The results of further compression

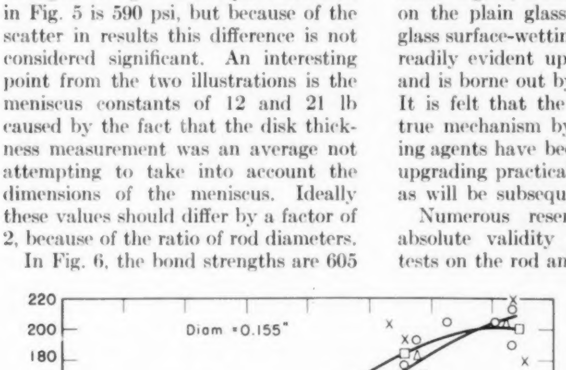

Fig. 6.—Force-thickness plot. Pyrex rods, plain glass, acetone-washed bond stress 605 psi. Meniscus constant, 11 lb. Finished glass, vinyl trichlorosilane (136). Bond stress 680 psi. Meniscus constant, 18 lb.

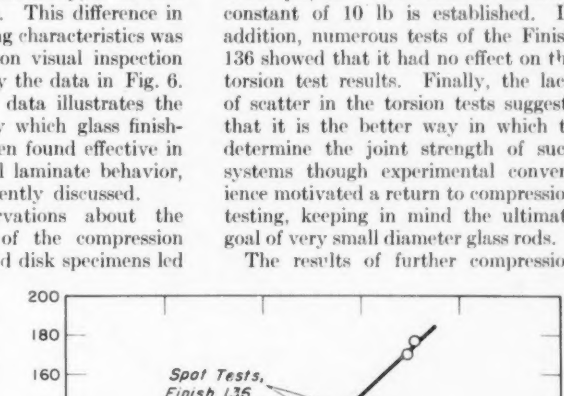

Fig. 7.—Interface-force disk-thickness from torsion tests. Acetone-cleaned and 136-finished Pyrex rods. Bond stress 963 psi. Meniscus constant, 10 lb.

tests are presented in Fig. 8 where three Pyrex rod diameters 0.08, 0.16, and 0.24 in. and four surface treatments were used with Paraplex P-43 disks. The heat-cleaned glass was exposed to 600 F for 12 hr in an air oven and the Volan A treatment was provided by Owens-Corning Fiberglas Corp. as Finish 139. In each plot, the broken line corresponds to a bond strength of 605 psi, previously found from the data in Fig. 6, with its zero thickness intercept suitably adjusted for measured meniscus constants. Each of the indicated points represents an average of 5 to 10 tests and it is seen that neither diameter nor glass finish has a significant effect on the bond strength. The lack of diameter effect suggests that the torsion test results, with a bond strength of 963 psi, might be indicative of the results to be found with much smaller rods, the torsion test producing a more uniform stress distribution at the glass-resin interface with less scatter and a higher apparent joint strength.

Mention has been made previously of the frictional resistance load exhibited by the specimen after fracture between the rod and disk has taken place. From Fig. 9, referring to compression tests, it can be seen that this effect appears slightly influenced by size and finish, but it must be kept in mind that the fractured surfaces are not perfectly reproducible, so the data may be misleading. More work is being done on this point. Approximate measurements of the coefficient of friction between cured polyester resin and flat glass surfaces indicate an average value in the range of 0.25 to 0.30. With this figure, the normal stress between glass and resin in a typical rod-disk torsion experiment is calculated to be approximately 2500 psi which, incidentally, is greater than the measured bond strength. Approximately 1000 psi of this can be accounted for by the difference in coefficients of thermal expansion of resin and glass, assuming "zero clearance" at the curing temperature of 150 F and cooling to 70 F. This suggests that the remainder of the normal stress is caused by the polymerization shrinkage of the resin (some 7 per cent on a volumetric basis). Because of the ambiguities necessarily surrounding such calculations and deductions (**3**) however, direct measurements of these shrinkage pressures will be made. It is interesting to note that the relative level of the frictional force is temperature sensitive, and by performing compression tests at −70 F an apparent bond strength of 1030 psi, or 170 per cent of the 605 psi room temperature value, was measured, with the force-deformation record as shown in Fig. 10 in which the "knee" previously evident in Fig. 2 has been eliminated by the additional thermal shrinkage of the resin disk.

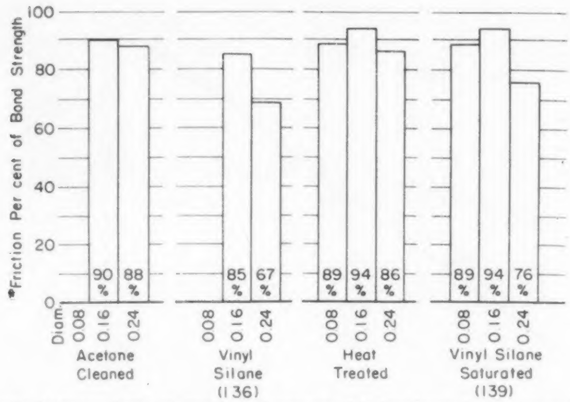

Fig. 9.—Ratio between bond strength and average friction force for Pyrex rod compression tests.

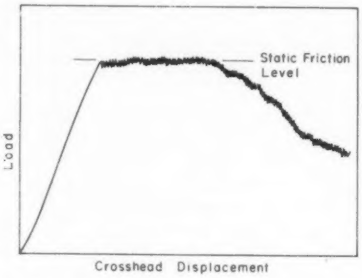

Fig. 10.—Typical force-displacement record from compression test at −70 F. Note absence of difference between bond and friction forces due to thermal contraction of disk upon rod.

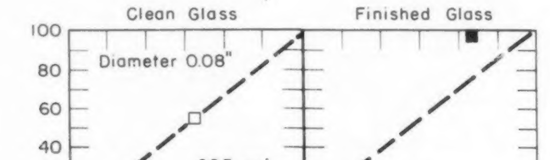

Fig. 8.—Force-disk thickness for Pyrex rods of various diameters and finishes. Each point average of 5 to 10 compression tests. Broken line represents bond stress of 605 psi in each plot.

A number of compression rod-disk specimens of various sizes and surface finishes were subjected to prolonged water immersion at 72 F prior to testing. The bond strengths so measured were the same as those for continuously dry specimens, approximating 600 psi, suggesting that the mechanism of water damage which occurs with commercial laminates did not take place with such specimens.

All of the results discussed to this point refer to polyester resin disks. In all such tests, either compressive or torsional, the fracture between rod and disk was a "clean" one apparently situated directly at the interface. No material transfer between the two components could be detected by microsopic examination of each, and hence, the use of radioactive tracers to locate the fracture plane is planned. In tests with polyester disks and rods in which the surfaces of the latter had been mechanically or chemically roughened prior to casting, the failure occurred by a flexural cracking of the disk or by a crushing and shattering of the rod at its supported end. The "strengths" so measured were many factors greater than the 605 psi value previously established, and in those cases where glass crushing did not occur it appeared that the cohesive strengths of the resin or the glass were approached. In many of these instances, the disk would break in flexure and pluck out large pieces of glass from the rod or appreciable amounts of the disk would remain adhered to the rod. By mechanically roughening the glass, the strength of the joint was greatly increased and the location of the fracture surfaces was completely altered. Precisely the same types of fractures, again at apparent stress values comparable to the cohesive strengths of the components, were observed with smooth surface Pyrex rods and disks of epoxy resin, Epon 828 cured with DTA. Bond strengths of several thousand pounds per square inch were consistently so measured and never has an epoxy-rod specimen failed cleanly at the joint between the two. To illustrate further the fundamental difference between the bonding actions of these two resins, another experiment was performed. Smooth glass rods were first coated with a very thin film of epoxy resin perhaps 0.003 to 0.006 in. thick, which was cured before a polyester disk was cast around the rod in the conventional manner. When tested, the joint strength and fracture modes were as if the entire disk were of epoxy: high bond stress and great breakage of resin and glass were observed. When the reverse was done, a thin polyester coating on smooth glass and then an epoxy disk, the joint behaved as if it were a polyester disk specimen with bond strengths of the order of 600 psi and very smooth fractures at the interface.

With respect to the polyester-smooth rod combinations, their actions very strongly suggest the existence of a thin layer of weak material directly at the interface between the two. This may be caused by a chemical reaction between the glass and the adsorbed water which is invariably present on its surface, producing a degraded zone of inferior strength in which the fracture takes place entirely unaffected by subsequent finish treatments such as those investigated. Alternatively, such adsorbed materials may locally contaminate the curing reaction of the polyester which is extremely sensitive to certain impurites in small amounts, thus producing a thin zone of improperly polymerized polyester having inferior mechanical strength. Strong arguments for either hypothesis can be offered; in any event, the weak zone is known to be very thin, though comparable in dimensions to commercial glass-fiber diameters. That a similar action does not take place with the epoxy resin has been ascribed to the presence, in the epoxy, of certain amine compounds which are both highly hygroscopic and perhaps capable of chemical reaction with the glass.

The third method of joint strength measurement, using the specimen shown in Fig. 3 with E glass rods of 0.010 and 0.020 in. diam, has been used in numerous tests thus far, with both paraplex P-43 polyester resin and Epon 828 epoxy resin. Though some experimental refinements remain to be accomplished, the average bond strengths so measured are essentially the same as found in the larger scale tests. It is expected that work presently in progress involving smaller diameters down to the filament size and various glass surface treatments will further confirm the results already established with the larger rod tests. Additionally, this third method may permit a more precise determination of the epoxy-glass bond strength, since the fractures in this system are local and do not completely destroy the specimen.

Discussion

It is felt that this research has illuminated the role of glass surface treatments in commercial laminates by disproving their hypothetical improvement of resin-glass bond strength. It is believed that they primarily control the degree of glass fabric wetting by the liquid resin, the better finishes facilitating a more complete penetration of the liquid into the interstices of the fibrous structure, displacing the air, coating each fiber and eliminating voids in the final composite which could serve as passageways for water. In finished laminates, an interesting correlation between moisture absorption and wet-strength retention can be found: if the moisture absorption is over 0.05 per cent the laminate has a modestly lower dry strength and loses as much as 40 per cent of this when wet. Such moisture pickups are invariably associated with the older finishes. If the absorption is in the region of 0.01 to 0.05 per cent, the laminate exhibits a somewhat higher dry strength and loses only a few per cent of this when exposed to water. This behavior is found only with the newer organic-silicon complex finishes mentioned previously. Since the surface finish apparently controls moisture absorption and wet-strength retention, with all other parameters being held constant it appears logical that the water enters a laminate and degrades its properties because the resin has failed to penetrate completely the fiber bundles and coat each fiber with an unbroken joint. Common sense suggests that this mechanism of water penetration is correct. Voids must exist for the water to enter the structure. Thus, the better the finish, the better the resin penetration and wetting of the glass fibers, the lower the void content, and the higher the wet-strength retention. No direct effect on bond strength by the glass finish is believed to exist.

The bond strength tests also reveal that even after the joint between resin and glass is broken, the load-carrying ability of the composite material remains substantial. That such fractures occur early in the life of a laminate is borne out by much practical experience. The familiar and abrupt decrease in stiffness when freshly prepared laminate specimens are first tested in tension is a commonly observed effect, with the "secondary" modulus of elasticity being about 70 to 90 per cent of the initial modulus in the low stress region, depending upon the form of the fibrous glass reinforcement used (**4**). Rarely, if ever, is the initial modulus again attained under cyclic loading. With the rod-disk specimens, precisely the same action has been repeatedly observed; the stiffness of the specimen after fracture between rod and disk is about 80 to 90 per cent of that prior to fracture, and the "strength" due to friction is about 75 to 95 per cent of that prior to joint fracture. The importance of friction in laminate behavior casts further doubt

on the concept of a specific interaction between finish and joint strength.

Manufacturers of fibrous glass reinforced pipe have all found it necessary to use an unreinforced and thus relatively flexible inner liner material to prevent "weeping" or gradual leakage of the fluid through the pipe wall when under working pressures. The pressure-created stresses distort the laminate and separate the glass fibers from the resin matrix, as in the experiments reported here, thus providing cracks for the fluid to follow through the pipe wall. The unreinforced liner distorts freely and without fracturing and prevents the liquid from reaching the cracks in the pipe wall.

From the foregoing results it would appear that epoxy-base laminates should be distinctly superior to polyester-base ones, though in practice this is not the case, a very small difference separating the dry-strength properties of the two. This apparent anomaly arises from the fact that masses of fibers rather than single glass elements are used in laminates and hence the strength performance of a resin matrix derives from a combination of its ductility, bond strength, and cohesive strength under the very complex distortion conditions experienced by the resin in a laminate. The cohesive strengths of both resins are nearly equal, though their elongations at fracture are somewhat different. That the great difference in bond strengths does not affect laminate performance is the subject of another phase of this research, to be reported at a later date. Without a detailed explanation it can be here stated that resin ductility and cohesive strength appear to control the strength properties of most laminates.

Conclusions

From the work to date the following conclusions appear justified:

1. Three methods of measuring the strength of glass-resin joints have been developed. They give comparable results, and one method should be useful for direct measurements with commercial-size glass fibers.

2. There is little effect of glass rod diameter on the joint strength over a range of diameters from 0.155 to 0.010 in.

3. Pyrex and electrical-grade glass, E glass, are indistinguishable in their behavior in these tests.

4. The surface-finish treatments of glass used in this research do not affect the strength of polyester-glass joints.

5. The strength of polyester-glass joints is far below the cohesive strength of either component unless the glass surface is roughened. The fractures in these low-strength joints appear to take place at the interface with no apparent material transfer occurring. The thickness of this fracture zone is very small.

6. Friction plays an important role in the action of most fibrous glass-resin laminates. This friction results from a combination of thermal and polymerization shrinkages of the resin about the glass. The magnitude of the normal pressure so created can be estimated. The friction occurs between glass and resin surfaces or between resin surfaces produced by fractures resulting from the great difference in stiffness of the two components.

7. Epoxy-glass joints approach, in strength, the cohesive strengths of both the resin and the glass. The failures of these joints demonstrate gross transfers of component materials and never occur at the glass-resin interface. The strength of such joints does not appear to be affected by glass finish or rod diameter.

Acknowledgment:

This work was performed in the M.I.T. Plastics Research Laboratory, A. G. H. Dietz, Director, which is supported by a Grant-in-Aid from the Manufacturing Chemists' Association, Inc. The reinforced plastics research program has been supported by funds received from the National Science Foundation, Owens-Corning Fiberglass Corporation, Shell Chemical Corporation, and Pittsburgh Plate Glass Company.

References

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(3) J. O. Outwater, Jr., "Mechanics of Plastics Reinforcement," *Proceedings*, Annual Technical and Management Conference, Reinforced Plastics Division, Soc. Plastics Industry, Vol. 11, Feb., 1956.

(4) E. C. O. Erickson and C. B. Norris, "Tensile Properties of Glass-Fabric Laminates with Laminations Oriented in Any Way," *Proceedings*, Annual Technical and Management Conference, Reinforced Plastics Division, Soc. Plastics Industry, Vol. 11, Feb., 1956.

The Bookshelf

Books reviewed here are furnished by publishers knowing of the broad interests of ASTM. Occasionally reviews are prepared by ASTM Staff members, but in most cases the books are reviewed by Society members or other individuals who are well informed on the subject at hand.

More attention is being given to the Bookshelf in an effort to make it a more useful service to members, by soliciting larger numbers of appropriate books and by actively seeking qualified volunteer reviewers. Members who wish to be considered for reviewing books are invited to send in their names and the subjects in which they are interested. Due to customs and mailing considerations, requests from the United States only can be considered.

Copies of these books are not available through ASTM; all inquiries concerning them should be addressed to the publisher.

Anti-Corrosion Manual

Corrosion Prevention and Control (Scientific Surveys Limited), 140 Cromwell Road, London, S.W. 7, England; 1958 edition; 8½ by 11 in.; 260 pp.

This first edition of a proposed yearly publication presents practical information on products, processes, and techniques used in preventing or mitigating corrosion. General principles of corrosion and general methods of preventing corrosion are explained. Fretting corrosion, as a unique type of corrosion, and cathodic protection including instrumentation are discussed. Specific methods of preventing or mitigating corrosion are presented under the following five main sections: Corrosion-Resistant Materials; Preparatory Treatment for Protective Coatings; Protective Paint Coatings; Other Protective Coatings (Plating, Spraying, and Dipping); Applied Wrapping and Spray Packaging. There are forty subsections contributed by representatives of the respective industries and trade associations, and others prominent in the control of corrosion in England. Both successful and unsuccessful applications of corrosion control are described, including detail of the functions and operation of the equipment treated. This, combined with the large number of contributors, necessarily results in some duplication of information. This is not objectionable, considering that the manual thus becomes a handier reference for anyone in search of information about a specific problem.

This manual should be of more value to the design engineer or maintenance engineer than to the research scientist or student. The reader may perceive a slight bias on the part of some of the contributors. This is understandable when it is considered that the contributor has an extensive background and interest in a specific material. Materials of construction are frequently referred to by trade names—a standards specification number, if available, or the approximate composition of the material would be of more value to the reader.

Advertisements account for approximately 20 per cent of the manual. A list of references is included at the end of each subsection. Subsequent editions are planned to cover each year's development and progress so that up-to-date, factual information will be available.

J. K. Deichler

Strength of Materials

F. R. Shanley; McGraw-Hill Book Co. New York, N. Y., 783 pp., $8.50.

This is a comprehensive textbook of interest to engineering and science students at the college level. The subject matter of strength of materials, in both its theoretical and applied aspects, is presented in a thorough and at the same time an interesting form. Sufficiently mathematical to permit rigorous portrayal of the principles involved, the topics are arranged for ready classroom presentation. The author divides the text into 28 chapters. Particular attention has been given to the "... order of presentation..." to facilitate the gradual and systematic development of the engineering concept of load distribution on structural members of varied shapes—an approach that is almost certain to be appreciated by engineering students and welcomed by many teachers.

It is expected that most users of this book will find the emphasis on the various aspects of strength of materials in keeping with the importance of the engineering applications and also research interest. Quite properly, there is emphasis throughout on the design stress and material relationship, which is of interest, and even of critical concern, to equipment and building designers. The designers for heavy construction will find this book a reliable source of reference. The subjects of statically indeterminate beams, buckling of columns, and local and lateral buckling are covered with thoroughness and clarity. These and other chapters throughout the book include a considerable number of suggested problems.

The use of this book as a text for engineers should bring to their training a good understanding of strength of materials. It is assumed that a course of this type would be supplemented by courses in engineering materials and physical testing, as well as the assignment of developmental problems in advanced engineering design.

The book is particularly well supplied with illustrative type problems, and the text material is indexed for ready reference. A list of 105 references is included. The printing, figures, and illustrations are clear, and the paper and binding are of superior quality. In summary, this reviewer finds the book an authoritative as well as a teachable text. A wide acceptance may be reasonably expected.

Harold L. Maxwell

Concrete for Radiation Shielding

American Concrete Inst.; Detroit, Mich.; 132 pp.; $4.00.

A new publication by the American Concrete Institute, *Concrete for Radiation Shielding* is a compilation of seven papers on the use of concrete for shielding nuclear radiation and the calculation of proportions and properties of various heavy concretes.

The papers included are Concrete for Radiation Shielding, Absorption by Concrete of X-Rays and Gamma Rays, Properties of High-Density Concrete Made with Iron Aggregate, Heavy Steel-Aggregate Concrete, Properties of Heavy Concrete Made with Barite Aggregates, Magnetite Iron Ore Concrete for Nuclear Shielding, and Proportioning of Mixes for Steel Coarse Aggregate and Limonite and Magnetite Matrix Heavy Concretes.

The Measurement of Colour

W. D. Wright; The Macmillan Co., New York, N. Y. (1958); 263 pp.; $10.75.

This comprehensive volume primarily describes the physiology of color vision and the physics of color measurements. In the first two chapters the author discusses the physical nature of light and its sources, as well as the physiological functions of color vision. These discussions are sufficiently detailed to enable the reader to gain an understanding of the basic attributes of the subject.

The principles of photometry and colorimetry are described in detail with algebraic and geometric analyses. Pictoral analogies and diagrams are used throughout to aid the reader in understanding the various phenomena. Mr. Wright's description of the experimental basis for trichromatic colorimetry may seem more complete and detailed than desired by some readers; however, the importance of these basic principles remains. The author has made a very good presentation of the history of development of the "standard ob-

(*Continued on page 74*)

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For blades (also vanes and buckets)

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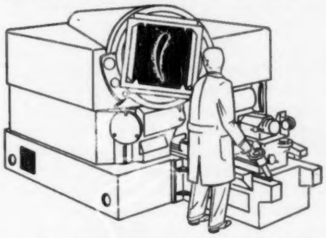
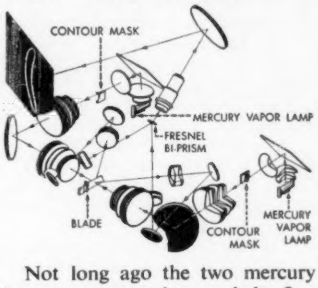


Therefore we have been busy lately building this large optical device. It works as follows:



Not long ago the two mercury lamps were turned on and the first cross-section of the first blade was seen in magnification against its tolerance envelope scribed on the screen. Inspection from now on should go well.

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Prices stated are subject to change without notice.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

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The Bookshelf

(*Continued from page 69*)

server," including the CIE standard coordinates, chromaticity chart, and distribution curves. Methods for calculation of tristimulus specifications from spectrophotometric data by the selected ordinate and weighted ordinate systems are systematically delineated. Included are the chromaticity coordinate system of color specification, and the dominant wavelength and purity system, and the merits of each. An excellent general description is given of various types of color-measuring instruments without descriptions of excessive technical details. Included are visual and photoelectric colorimeters, and spectrophotometers such as the Wright, Guild, Hardy (GE), and Beckman instruments.

The implications of various physical measurements possible and their relationships to visual perception of color appearances and differences are discussed with references to the many studies that have been made on perceptible color differences: included are those made by Wright, Judd, MacAdam, and others. Mr. Wright describes many of the color atlases and some of their individual applications. Particular emphasis is on the Munsell system. In the final chapters of the book the author has included some very interesting descriptions of various applications of color data which are in daily use in many industries (or for which there are potentialities). In these chapters he discusses color photography, printing, and television, and touches on the difficulties involved in the visual assessment of a color picture. Particularly interesting is Mr. Wright's description of the television industries' use of the additive principles of color mixture in their development of the American color television system. In discussing the practical applications of colorimetry, the author proceeds to classify the various color problems and then touches on many of the diversified fields: among these he has included chemicals, lighting, agriculture and food, clinical, pulp and paper, paint, signal glasses, optical phenomena, astronomy. Each of these is touched on lightly but tastefully to present the reader with a general concept of the varied implications of color measurement from a pragmatic viewpoint. In the appendix are included tables useful in the calculation of color data.

Dr. Wright has done an excellent job of organizing the material in his book in a manner which greatly aids the continuity of the subject. The author (Professor of Technical Optics at the Imperial College of Science and Technology, South Kensington, England) considers instruments in common use in many countries, telling of some of the various advantages and disadvantages of each. The data included in the tables in the appendix make the volume complete enough within itself to be very usable as a text. The volume as a whole would be a beneficial reference for those involved in color measurement work who are interested in a more comprehensive understanding of the basis of such physical color measurement procedures as those of the ASTM.

B. W. Preston

The Analysis of Rubber and Rubber-Like Polymers

William C. Wake; MacLaren & Sons, Ltd. London, England (1958); 256 pp.; $8.

This recent work can be expected to become very popular in the field, particularly in small rubber laboratories with limited facilities. It is easy, in fact enjoyable to read, and contains not only a wealth of analytical material but a good share of theory and detailed discussion concerning some difficult analyses. Its one fault, from the standpoint of users of ASTM and other standard methods, is the lack of detail on British Standards Institution methods, which are not generally available in this country.

Of particular interest to ASTM method users are the chapters on extraction, qualitative analysis for polymer type, elemental analysis of polymers, direct determination of polymer functional groups including unsaturation, solution, and dissolution methods, and analysis of extracts for sulfur, antioxidant, accelerator, and plasticizer.

Dr. Wake quotes freely from ASTM publications on natural and synthetic rubber analysis. However, of more interest to active members of the analytical subcommittees of ASTM product committees dealing with this subject is the cogent criticism leveled at many of the ASTM tentative methods. He refers particularly to some methods on identification and analysis of synthetic elastomers which are at best obsolescent, and in some cases useless. Subcommittee on Chemical Analysis of Committee D-11 on Rubber realizes the need for revision of these methods and is actively engaged in revising them at the present time. Criticism of this type is welcomed, especially when the critic presents a better method.

Another criticism leveled at ASTM procedures concerns the definition and method of determination of free sulfur in rubber compounds. We are probably wedded to this method by long usage and the fact that it serves a useful purpose, but there undoubtedly should be some changes made in the direction of scientific truth. Strangely, Dr. Wake does not criticize some ASTM methods which we consider obsolete and are interested in

(*Continued on page 76*)

SARGENT RECORDER

(*Continued from page 74*)

revising, while some of his methods appear to us to be obsolescent.

Perhaps one of the greatest services Dr. Wake has performed in this work is to give users of ASTM and BSI methods explanation of when and how to use the methods and how to interpret the results. In spite of all the care taken by ASTM and BSI in writing adequate scopes for their procedures, it is never quite possible to transmit real appreciation of the methods to the user except in a critical work of the type exemplified by Dr. Wake's book.

WILLARD C. WAKE
Chairman, Subcommittee on Chemical Analysis, Committee D-11 on Rubber

A Handbook of Hard Metals

W. Dawihl; Philosophical Library, Inc., (1956); 180 pp.; $10.00.

MATERIALS CONTAINING carbides of the high melting point metals as their chief constituents are finding increasing application, and the relative paucity of literature on these materials lends interest to this book, which is a somewhat incomplete translation of Dr. Dawihl's *Handbuch der Hartmetalle* published before World War II.

The author classifies hard metals into three groups: sintered alloys containing principally one or more hard carbides, tungsten-carbide-base alloys formed by melting, and the pure carbides themselves which are used as hard facings. The first of these groups, comprising the cemented carbides used extensively in metal cutting, is by far the most important. The title of the book naturally leads to the expectation of something approaching encyclopaedic information on all aspects of hard metal carbides, and this anticipation is reasonably well fulfilled. The chemistry of formation of the important metal carbides, and of some mixed carbide crystals, is adequately discussed, and some binary and ternary phase relationships are considered. This phase of the book would undoubtedly be improved by an up-to-date revision, but it does at least cover the background necessary for an understanding of the technical production of hard metals. Numerous references to original publications are given, and this commendable practice makes the book a useful initial reference for potential researchers in this field. Subsequent chapters cover the chemistry and technological aspects of sintering, the wearing characteristics and other properties of hard metals, tungsten-free materials, and the industrial aspects of hard metal production. The manufacture and application of tools was not included in the manuscript available for translation, and these subjects are not discussed. It is to be hoped that any future edition will remedy this omission. At the same time it might be remarked that some present and potential uses of metal carbides involve exposure to high temperatures, so that information on the appropriate thermodynamic properties would be useful. Such information is available for some carbides and would represent a useful addition to the text.

The above deficiencies are relatively minor, and the book can be highly recommended to all interested in hard metals.

R. A. DODD

Review of Standards for Cements other than Portland, 1958

Cembureau, *The Cement Statistical and Technical Assn.*, Malmo, Sweden (1958); 164 pp.; Sh 30/- (Approximately $4.25); in English.

THIS publication is the second of its type sponsored and published by The Cement Statistical and Technical Assn., Sweden, the first

(*Continued on page 77*)

The Bookshelf

(*Continued from page 76*)

being a *Review of the Portland Cement Standards of the World, 1955*.

The booklet contains practically all of the standard specifications for binding agents for construction and building purposes generally referred to as cement, excluding portland cement which is covered in the companion review referred to. These specifications are grouped according to type, such as blast furnace, pozzolanic, natural, masonry, mixed portland cements, and others.

A chapter on each type of cement is included which contains a summary of pertinent characteristics and specification requirements arranged according to each country and providing reference to the nationally recognized standards.

All in all, this review provides a wealth of information by which comparison can be made from one country to another of the specification requirements being used. The information is given concisely, and the book is well organized.

OTHER SOCIETIES EVENTS

February 3–5—**Society of the Plastics Industry,** 14th SPI Reinforced Plastics Div., Edgewater Beach Hotel, Chicago, Ill.

February 8–13—**American Society of Civil Engineers,** Statler Hotel, Los Angeles, Calif.

February 15–19—**National Sand and Gravel Assn.** and **National Ready Mixed Concrete Assn.** Conventions, Roosevelt Hotel, New Orleans, La.

February 15–19—**American Institute of Mining, Metallurgical and Petroleum Engineers,** Annual Meeting, St. Francis, Sheraton-Palace, and Sir Francis Drake, San Francisco, Calif.

February 19–21—**National Society of Professional Engineers,** Winter Meeting, Dinkler-Tutwiler Hotel, Birmingham, Ala.

February 23–26—**American Concrete Institute,** Annual Meeting, Statler Hilton Hotel, Los Angeles, Calif.

March 9–10—**Steel Founders' Society of America,** 57th Annual Meeting, Drake Hotel, Chicago, Ill.

March 9–11—**American Railway Engineering Assn.,** Annual Meeting, Sherman Hotel, Chicago, Ill.

March 16–20—**American Institute of Chemical Engineers,** National Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

March 16–20—**National Assn. of Corrosion Engineers,** National Meeting, Sherman Hotel, Chicago, Ill.

March 16–20—**American Society for Metals,** Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

March 23–26—**Institute of Radio Engineers,** National Convention, Coliseum and Waldorf-Astoria, New York, N. Y.

March 26–27—**Society of the Plastics Industry,** 16th Pacific Coast Section Conference, Hotel Del Coronado, Coronado, Calif.

April 2–3—**The Metallurgical Society of AIME, Electrochemical Society, National Association of Corrosion Engineers,** and **ASTM,** Technical Conference on "Physical Metallurgy of Stress-Corrosion Fracture," Mellon Institute, Pittsburgh, Pa.

April 5–10—**Fifth Nuclear Congress,** Public Auditorium, Cleveland, Ohio

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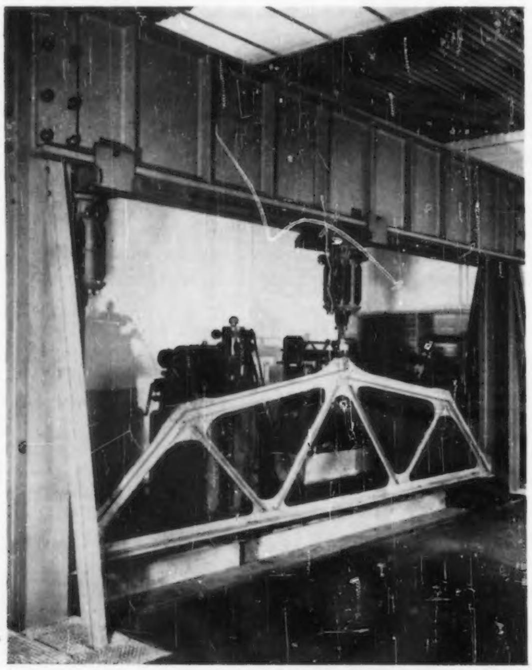

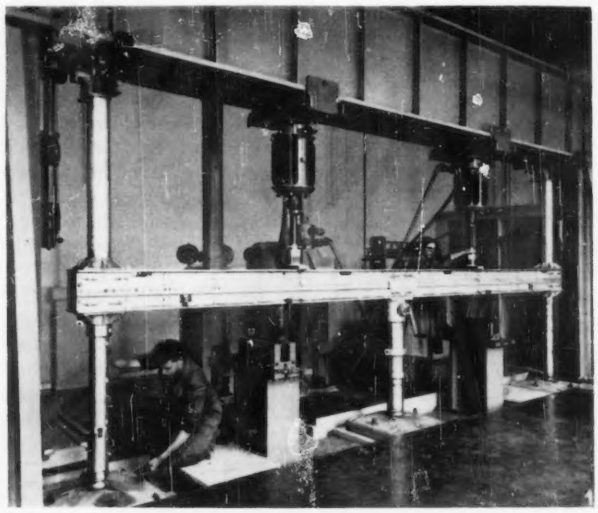

For detailed descriptive literature, write or phone any of the three Carl Hirschmann Company offices

NEW MEMBERS.......

The following 16 members were elected from November 13 to December 16, 1958, making the total membership 9609....... Welcome to ASTM

Note: Names are arranged alphabetically—Company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts.

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Bodor, Stephen J., instructor, Mathematics and Physics Dept., Lowell Technological Inst., Smith Hall, Lowell, Mass.

Morgan, C. T., president, C. T. Morgan Co., 21 Lothrop St., Beverly, Mass.

Tons, Egons, research engineer, Civil and Sanitary Dept., Massachusetts Institute of Technology, Rm. 1-025, Cambridge 39, Mass.

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Colvin, Floyd E., laboratory manager, Research and Development Dept., Cuno Engineering Corp., 80 S. Vine St., Meriden, Conn.

Dunn, E. J., chief metallurgist, The Plume & Atwood Manufacturing Co., Thomaston, Conn.

Erickson, G. L., technical supervisor, Plastics and Coal Chemicals Div., Allied Chemical Corp., 40 Reactor St., New York 6, N.Y.

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Sperry Farragut Co., Division of Sperry Rand Corp., E. R. Tretler, quality control manager, Bristol, Tenn.

WASHINGTON (D.C.) DISTRICT

Steinman, G. C., chief, Marine Engineering Section, Merchant Marine Technical Div., U. S. Coast Guard, Rm. 4120, 1300 E St., N.W., Washington 25, D. C.

OTHER THAN U. S. POSSESSIONS

Bombay Textile Research Assn., C. Nanjundayya, joint director, Jyoti 287, Sion Rd., E. Bombay 22, India.

Crossman, A. W. C., chief mechanical engineer, South Australian Railways, Box 401 B, G. P. O., Adelaide, South Australia.

Jones, R., technical librarian, DeHavilland Propellors, Ltd., Hatfield, Hertfordshire, England.

Nilforoushan, Ali, construction inspector, Harza Engineering Co., Internat., 22 Ave. Farvardin, Tehran, Iran.

Pattison, K. R., city engineer, City Engineers Dept., City Hall, Regina, Sask., Canada.

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

Among the newly elected officers of the American Council of Independent Laboratories are two ASTM members—**Cecil M. Shilstone,** partner, Shilstone Testing Laboratory (president); and **Lewis E. Harris,** director, Harris Laboratories (vice-president and president-elect).

Armco Steel Corp. announces the retirement of **Dr. A. L. Feild. M. E. Carruthers** has been named director of stainless steel research, succeeding Dr. Feild who is retiring after 27 years. **F. K. Bloom** will become manager of the research laboratory at the Baltimore Works, a position also formerly held by Dr. Feild. Dr. Feild represented Armco's company membership at Baltimore in the Society and on ASTM Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.

Dan Bailey, formerly project engineer, National Rocket Corp., Los Angeles, Calif., is now ordnance engineer, Kirk Engineering Co., Los Angeles. He is residing in Salt Lake City, Utah.

Russell E. Barnard has retired as advisory engineer for Armco Steel Corp., Middletown, Ohio. He had been active in the work of Committees A-1 on Steel and D-18 on Soils for Engineering Purposes. Mr. Barnard is now residing in Tucson, Ariz.

Walter Brown, previously consulting engineer, Angola, Ind., is now engineering design specialist, Preliminary Design, North American Aviation, Inc., Columbus, Ohio.

Theodore Irving Coe had a very complimentary editorial in The Washington Post of November 18 on his retirement from the chairmanship of the District of Columbia Board of Zoning Adjustment. The editorial complimented him for his service of more than two decades, extending over the entire life of the Board. He was given a Meritorious Public Service Award at a special luncheon in his honor. Mr. Coe has represented the American In-

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Personals

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stitute of Architects, Department of Education and Research, in ASTM for many years, and has been extremely active, serving as an officer and member of numerous technical committees. In June, 1958 he received the Society's coveted Award of Merit, recognizing outstanding service. Mr. Coe continues as the technical secretary of the AIA, which he has served for many years. His activities in ASTM and AIA belie his 87 years.

John G. Dempsey is now president of Prestcrete Corp., Plano, Ill. Formerly he was civil engineer and general manager, Compania Anonima de Concreto, Bachaquero Estado, Zulia, Venezuela.

Norman L. Deuble has been named to head a task force organized to develop uses of molybdenum metal and molybdenum-base alloys at Climax Molybdenum Co., New York. Walter F. Craig, Jr., will succeed Mr. Deuble as manager of metallurgical development.

Porter K. Dobbins, until recently civil engineer, Childersburg Development Corp. Childersburg, Ala., is now structural designer, Brown & Root Inc., Houston, Tex.

Harold F. Dodge, professor of Applied Mathematical Statistics, Rutgers University, formerly quality results engineer, Bell Telephone Labs., long-time member of the Society and past chairman of ASTM Committee E-11 on Quality Control, was honored at a ceremonial meeting of the American Statistical Assn. in Chicago on December 29, 1958. He addressed the section on Physical and Engineering Sciences on "Acceptance Sampling."

Wilfrid Fall has been made assistant vice-president in charge of railroad passenger car engineering for Pullman-Standard Car Mfg. Co., Worcester, Mass.

R. B. Feuchtbaum, until recently head, Materials Testing Lab., Freed Transformer Co., Brooklyn, N. Y., is now materials and processes engineer, Hughes Aircraft Co., Airborne Systems Lab., Materials and Processes Section, Culver City, Calif.

J. H. Foote, president and chief engineer of Commonwealth Associates, Inc., Jackson, Mich., was presented a plaque by the American Institute of Electrical Engineers in acknowledgment of his services as a vice-president of the Institute during 1956–1958. He is very active in ASTM, serving on a number of technical and administrative committees, and is an honorary member of the Detroit District Council.

Howard L. Gerhart was made director of research and development for the Paint and Brush Division of Pittsburgh Plate Glass Co., Pittsburgh, Pa. Previously Dr. Gerhart was director of research, Research Center, Springdale, Pa.

D. W. Hange is now hydraulic engineer, Jacksonville, Fla. District, U. S. Army Corps of Engineers, Neptune Beach, Fla.

G. E. Hutchinson has been appointed material and process engineer by Crucible Steel Co. of America, Pittsburgh, Pa. He will set up standards for measurement and analysis of product quality and yield.

Charles K. Johnson, formerly sales engineer, Baldwin-Lima-Hamilton Corp., Schenectady, N. Y., is now affiliated with Allegany Instrument Co., Inc., Cumberland, Md., as sales manager.

Rolland E. Johnson, previously research chemist, Metal and Thermit Corp., Highland, Ind., has joined The Youngstown Sheet and Tube Co., East Chicago, Ind., as chemical engineer.

William R. Johnson, formerly chief research metallurgist at the Associated Spring Corp. research center in Bristol, Conn., has been appointed assistant director of research and development.

William P. Kliment, engineer of standards, Crane Co., Chicago, Ill., has been awarded The Standards Medal for his "indefatigable efforts and outstanding achievements in the practical development and application of voluntary standards." This is one of the highest awards given by the American Standards Assn. Mr. Kliment is active on many ASTM technical committees.

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George H. Knode of the Physical Lab., Test Dept., The Pennsylvania Railroad Co., Altoona, Pa., retired October 31, 1958. He was a member of the Society since 1940, and served on ASTM Committee C-16 on Thermal Insulating Materials.

B. S. Kudravetz, formerly power engineer, United Engineers and Constructors, Inc., Phila., Pa., is now affiliated with Naval Air Material Center, Naval Air Eng. Facility (SI), Naval Base, Phila.

William L. Lamar has been elected chairman of the Division of Water, Sewage, and Sanitation Chemistry of the American Chemical Society. Dr. Lamar represents the U. S. Geological Survey, Quality of Water Branch, Menlo Park, Calif., on ASTM Committee D-19 on Industrial Water.

M. Robert Larson, formerly metallurgical engineer, Holcroft and Co., Detroit, Mich., has joined the staff of J. A. Kozma Co., Dearborn, Mich.

Maurice J. Lefebvre is now mill metallurgist, Anaconda Aluminum Co., Terre Haute, Ind. Previously he was technical director of R. D. Werner Co., Greenville, Pa.

Frederick S. Mallette, until recently consultant, Riverside, Conn., is now executive secretary, Committee on Air Pollution Controls, The American Society of Mechanical Engineers, New York, N. Y.

Thomas Matthews, laboratory manager, Atlas Supply Co., Newark, N. J., retired December 31, 1958. He was a member of the Society for a number of years.

J. D. Mattimore was made vice president for product engineering and research, Tube Turns Div., Chemeron Corp., Louisville, Ky. He had been director of product engineering and research.

Grant A. Mickelson has been promoted to associate director of research, Morton Chemical Co., Woodstock, Ill.

Stephen A. Montanaro, formerly managing director, City Testing and Research Labs., Inc., New York, N. Y., is now president of Academy Testing Labs., Inc., New York, N. Y.

Herbert F. Moore, research professor of engineering materials, Emeritus, University of Illinois, was honored at a luncheon at Urbana, Ill., on November 7, 1958, by the American Railway Engineering Assn. and the American Iron and Steel Inst. At that time a bronze plaque was presented to the University of Illinois in recognition of Professor Moore's pioneering and preeminence in the study of the fatigue properties of metals and especially his successful direction from 1931 to 1944 of the joint investigation of fissures in railroad rails, which contributed to the safety and economy of railroad operation. The plaque will be mounted permanently in the Talbot Laboratory. Professor Moore has been a member of ASTM since 1903, is a Past-President of the Society and was awarded Honorary Membership in 1938. He has also made valuable contributions to many of the Society's technical committees.

H. W. Mossman, metallurgist, Kennecott Copper Co., Chino Mines Div., Hurley, N. Mex., retired in November, 1958. Mr. Mossman represented the company's membership in the Society for a number of years.

Boro Nijhawan, director, National Metallurgical Laboratory, Jamshedpur, India, was the recent recipient of the award of Padma Shri, in recognition of his exceptionally distinguished services in the fields of science in India.

Thomas V. Parke, manager, Beckman Instruments, Inc., Scientific Instruments Div., Fullerton, Calif., has been appointed director of product standards.

Garnet P. Phillips has been appointed foundry research consultant, manufacturing research, for International Harvester Co., Chicago, Ill. Since 1949 he was general supervisor of foundry research.

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Personals

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Lewis H. Rogers, formerly senior chemist, Air Pollution Foundation, San Marino, Calif., is now associate director, Vitro Laboratories, West Orange, N. J.

Eugene J. Rosenbaum, formerly of the research and engineering department of Sun Oil Co., is now professor of chemistry at Drexel Institute of Technology, Phila., Pa.

Alex Sacher has been appointed to the newly created post of vice-president of commercial development, Hudson Pulp & Paper Corp., New York, N. Y. Previously he was affiliated with Standard Insulation Co., East Rutherford, N. J., as technical director.

Gilbert R. Semans, until recently director of research and technology, Jessop Steel Co., Washington, Pa., is now chief steel metallurgist, A. M. Byers Co., Pittsburgh, Pa.

Paul H. Sherrick is newly elected vice-president of E. H. Sargent & Co., Chicago, Ill. Previously he was treasurer and officer in charge of research and production.

John S. Smart, Jr., formerly assistant director of research has been appointed general sales manager, American Smelting and Refining Co., New York, N. Y.

Earle C. Smith, chief metallurgist and director of research at Republic Steel Corp., Cleveland, Ohio, was signally honored on two occasions. Ohio State University conferred on him the degree of honorary doctor of science, and The Verein Deutscher Eisenhüttenleute made him a "Foreign Honorable Member." Mr. Smith, a member of the Society for many years, serves on Committee A-1 on Steel.

Robert B. Sosman, professor of ceramics, Rutgers University, New Brunswick, N. J., recently received the Trinks Award, highest honor of the industrial heating industry, for his pioneering research in silica, steelmaking refractories, and pyrometry. The presentation was made to him at the annual banquet sponsored by the Trinks Industrial Heating Award Committees in Pittsburgh. Professor Sosman has been active in ASTM committee work for many years.

Manuel Tama is now president of Ajax Engineering Corp., Trenton, N. J. Formerly he was vice-president.

John R. Townsend, special assistant, Office of Assistant Secretary of Defense (Research and Engineering) has been elected president of the American Standards Assn. A Past-President of ASTM. Mr. Townsend is an outstanding authority on standards work.

Fred J. Walls, although recently retired from The International Nickel Co., Inc., Detroit, is continuing his membership in the Society. He is now affiliated with Engineering Castings, Inc., Marshall, Mich., in the capacity of vice-president.

Linwood A. Walters has been appointed director of research and development for National Vulcanized Fibre Co., Wilmington, Del.

Kurt F. Wendt, dean of the college of engineering, University of Wisconsin, has been appointed a member of the National Research Council. Dean Wendt will represent the American Society for Engineering Education in the division of engineering and industrial research on the council.

Sidney Werthan received the 1958 George B. Heckel Paint Industry Award from the Federation of Paint and Varnish Production Clubs. He was recognized for his work in the development of technical information on zinc pigments and their application in paint products. Mr. Werthan has represented the New Jersey Zinc Co. on Committee D-1 on Paint for many years.

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Personals

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E. R. Williams retired November 30, 1958, as director, Research Center, Johns-Manville Products Corp., Manville, N. J. He represented the sustaining membership of his company in the Society for many years. Mr. Williams is succeeded by **Mr. G. B. Brown.**

Raymond W. Woodward retired from Underwood Corp. December 31, 1958, as executive staff consultant. Dr. Woodward has been a personal member of the Society since 1918 and representative of his company's membership since 1940. For many years he served on several technical committees of ASTM, and also on the New England District Council. We are happy that Dr. Woodward plans to continue his association with personal membership in the Society. **Mr. Walter E. Borin** will succeed Dr. Woodward as representative of Underwood's membership in ASTM.

Steven Yurenka, until recently associated with Douglas Aircraft Co., Santa Monica, Calif., as material and process engineer, is now chief engineer, Narmco Industries, Inc., Research and Development, Ranco Santa Fe, Calif.

ASTM members number among the recipients of awards given by The American Society of Mechanical Engineers at the 1958 Annual Meeting:

Wilbur H. Armacost of Combustion Engineering, Inc. was awarded the ASME Medal for distinguished service in engineering and science. Mr. Armacost is a member of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

Vivian F. Estcourt, general superintendent of steam generation, Pacific Gas and Electric Co., was awarded the 1958 Prime Movers Committee Award for his paper, "Plant Management and Other Factors Affecting Maintenance Costs in Steam Generating Stations." Mr. Estcourt is an active member of Committee D-2 on Petroleum Products and Lubricants.

Dr. Arpad L. Nadai received the Timoshenko Medal for his contributions to the theory of elastic plates and the flow and fracture of solid bodies. A member of the Society for many years, Dr. Nadai served on several special ASTM technical committees and was the Edgar Marburg lecturer in 1931.

Ernest L. Robinson was signally honored by election to ASME Honorary Membership, recognizing his outstanding contributions to the field of steam generation of power. His long-time and constructive efforts in ASTM were especially concentrated in the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals which he headed for several years. Now retired from General Electric Co., Mr. Robinson resides in Schenectady, N. Y.

Harold J. Rose, vice-president and director of research, Bituminous Coal Research, Inc., was awarded the 1958 Worcester Reed Warner Medal in recognition of the valuable work which he has done in investigating and reporting the characteristics of coals, the benefication of coal by various processes and the use and control of combustion by-products, specifically fly ash and atmospheric contaminants. Mr. Rose is a long-time member of ASTM and is active in the work of Committee D-5 on Coal and Coke.

DEATHS...

F. E. Amthor, treasurer, The Amthor Testing Instrument Co., Inc., Brooklyn, N. Y. (November 29, 1958). Mr. Amthor joined the Society in 1926 and had been a member of Committee D-13 on Textile Materials since that time.

C. C. Clogston, Associate chemical engineer, Underwriters' Laboratories, Inc., Chicago, Ill. (October, 1958). He represented Underwriters' Laboratories on ASTM Committee A-5 on Corrosion of Iron and Steel for a number of years.

Paul J. DeKoning (June, 1958). Professor DeKoning represented the Department of Applied Mechanics, Michigan State University, in the Society.

Samuel A. Gordon, technical consultant, Battelle Memorial Institute, Columbus, Ohio (October 26, 1958). He had been a member of the Society since 1949,

and served on ASTM Committees E-9 on Fatigue, E-1 on Methods of Testing, and the Administrative Committee on Simulated Service Testing.

Charles B. Karlson, president, Steel Products Corp., New York, N. Y. (recently). He had been a member of the Society since 1929.

C. C. Kelsey, manager, Asbestos-Cement Products Assn., New York, N. Y. (suddenly, December 13, 1958, as the result of a heart attack). He represented the Association's membership in the Society for many years. Mr. Kelsey made many valuable contributions to the work of Committee C-17 on Asbestos-Cement Products, and served as secretary of that committee for 10 years.

C. F. Kettering, director and consultant, General Motors Corp., Detroit, Mich. (November 24, 1958). He joined the Society in 1915 and continued his membership until the time of his death. In 1948 he retired as vice-president of General Motors Corp. Really the founder and for many years prime mover of the General Motors Research Laboratories, "Boss" Kettering was not active in ASTM although he did speak in his inimitable way at several ASTM meetings. Many of his close associates have given outstanding service to the Society, including ASTM Past-Presidents F. O. Clements (deceased), T. A. Boyd, Director H. C. Mougey, and others.

James T. MacKenzie, consultant, Southern Research Inst., Birmingham, Ala. (November 18, 1958). He joined the Society in 1918 and was both a Life Member and Honorary Member. Mr. MacKenzie's participation in many technical committee activities dates back to 1926. He had been a Director of the Society, and also was one of the original councilors of the Southeast District.

C. P. Van Gundy, Aberdeen, Md. (November 11, 1958). Prior to his retirement in 1938, Mr. Van Gundy was with the Baltimore & Ohio Railroad Co. for many years having served in several capacities. His membership in the Society dates back to 1903, and continued on to the time of his death. He formerly represented the B & O's company membership in ASTM. Mr. Van Gundy's technical committee activities included D-1 on Paint, A-1 on Steel, and D-2 on Petroleum Products and Lubricants. From 1915 to 1928 he served as Chairman of D-2, and in recognition of his many years of service and valued contributions to the work of that committee he was elected to honorary membership. In 1955 the American Chemical Society had a feature article on Mr. Van Gundy, indicating that he held the longest continuous membership in ACS, 64 years of continuous activity.

Wilbur M. Wilson, research professor of structural engineering, Emeritus, Department of Civil Engineering, University of Illinois (November 28, 1958), at Urbana, Ill. at the age of 77. Professor Wilson joined the Society in 1919 and was a member until his retirement in 1949. He was a consulting member of ASTM Committee E-9 on Fatigue. Professor Wilson was the recipient of many awards and honors for many awards and honors for his outstanding work in the field of metals.

T. A. Werkenthin, U. S. Navy, Bureau of Ships, Washington, D. C., (recently). For many years, Mr. Werkenthin, representing the Bureau of Ships, made valuable contributions to the work of Committees D-20 on Plastics, D-11 on Rubber and Rubber-Like Materials, and E-1 on Methods of Testing.

W. Herbert Fulweiler, a member of the Society since 1909, Past-President and Honorary Member of ASTM, (Dec. 20, 1958). For many years he was affiliated with the United Gas Improvement Co., Philadelphia, Pa., as a chemical engineer, and more recently he was a consulting chemist. Mr. Fulweiler's technical committee activities were legion; he had served as chairman of several committees. In 1952 he was elected to Honorary Membership of Committee D-4 on Road and Paving Materials in recognition of his outstanding contributions and service to the work of that committee. For many years he was chairman of the Society's important Committee E-1 on Methods of Testing.

NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note. This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

LABORATORY ITEMS

Test Cabinet—Through the use of newly-designed cams, the versatile Aminco Climate-Lab enables manufacturers to meet many new federal and military specifications. The apparatus, a highly precise environmental test cabinet with program control, produces a wide variety of climatic conditions for various types of product testing.
American Instrument Co., Inc. 1812

Rectifier—A new line of compact, heavy-duty, electromechanical a-c voltage regulators is announced. Called the Selenivac, these precision units are designed for 25, 50, 60 or 400 cycle operation and provide ±1 per cent control with no wave-form distortion.
American Rectifier Corp. 1813

Radiation Foils—Thin foils for use in radiation measurement for various nuclear applications are now available. The foils range in thickness from 0.010 in. down to 0.00005 in. in such metals as copper, beryllium copper, gold, lead, nickel, palladium, platinum, tantalum, titanium, zinc, and stainless steel.
American Silver Co. 1814

Timer—Elimination of eye-squint for easier and more accurate reading is an advantage claimed for a new group of giant dial stopclocks now offered. Applicable to diversified timing jobs in science, photography, and industry, the stopclocks—having spring-wound movements for 48-hr running—operate and read exactly the same as stopwatches.
Andrew Technical Supply Co. 1815

Spectroscope—Rapid chemical identification and analysis by direct, visual spectrochemical means is possible through use of the Fuess Metal Spectroscope.
Applied Research Labs., Inc. 1816

Light Source—Larger and more powerful than its predecessor, the Aristo Mic-O-Lite II features four rings of "cold" light in a doughnut-type reflector six in. in diameter which provides a 2¼-in. aperture in its center.
Aristo Grid Lamp Products, Inc. 1817

Insulation Tester—Model 4501 Automatic Insulation Materials Tester meets requirements of some 30 ASTM specifications for electrical insulating materials such as varnishes, paper, tape, glass, phenolics, and rubber in rods, tubes, sheets, etc. This new 35-kv Hypot is offered for production, design, and research engineers using insulating materials.
Associated Research, Inc. 1818

Convection Oven—Hazard-safe ovens minimize the danger of sudden internal pressures or "sparking," protect safety of personnel and qualify under insurance regulations. They are designated according to Underwriters' Requirements (Class 1, Group D).
Blue M Electric Co. 1819

Stirrer—A new laboratory motor stirrer capable of stirring highly viscous liquids

at high or low speeds has been designed. The new variable speed unit provides consistent stirring action at selectively controlled speeds ranging all the way from 100 to 1500 rpm.
Central Scientific Co. 1820

Rod Clamp—The Bryden rod clamp is made of aluminum and equipped with stainless steel socket set screws operated by a conveniently shaped key or aluminum thumb screw. It is designed specifically to answer strict laboratory requirements for a clamp to be used in semi-permanent setups.
Chandler and Stedman 1821

Tension Analyzer—All types of wire may be checked for tension variations during coil winding with the Tension Analyzer. The Tension Analyzer, Brush Model BL-825, aids the manufacturer in producing uniform wire coils at optimum high winding speeds.
Clevite Corp. 1822

Vibration Pickup—Designed for vibration-analysis problems, the Type 4-118 is especially valuable in situations where space is limited, or where a heavier pickup would invalidate test results.
Consolidated Electrodynamics Corp. 1823

Oscillogram—A thermistor drum temperature control is one of several new features incorporated in this new 23-109A Oscillogram Processor, a completely self-contained portable motorized unit used by test installations for daylight processing of oscillograms.
Consolidated Electrodynamics Corp. 1824

Balancing Machines—A new series of completely automatic Schenck Vertical Balancing Machines for either one or two-plane balancing (static or dynamic) is now available. These machines are made in five standard sizes and cover weight capacities from 0.5 to 1100 lb.
Cosa Corporation 1825

Metal Tester—Non-destructive testing and sorting of accidentally mixed or incorrectly processed metal parts can be done speedily by the new Model C-2 Cyclograph. The instrument can be used on either ferrous or non-ferrous metals and will sort new stock, semi-finished, or finished parts by their metallurgical characteristics such as analysis, hardness, structure, case depth, etc.
J. W. Dice Co. 1826

Microscope—Built especially for industrial plant use, this new, erect-image, low-power microscope combines fine precision with unusually low cost. Users find it ideal for product inspection, materials examination and tedious assembly work.
Edmund Scientific Co. 1827

Optical Polygons—Multi-faced mirrors of glass or steel are used with optical tooling instruments to set up and test for squareness, angles, and circular spacing.
Engis Equipment Co. 1828

Quiet Sieve-Shaker—The patented features of the variable-speed Fisher/Wheeler Sieve Shaker make it ideal for mining laboratories, glass and cement makers, and manufacturers of graphite, pigments, detergents, metal powders, and a wide variety of chemicals. It will handle all the regular ASTM and other standard sieving tests.
Fisher Scientific Co. 1829

Autotransformer—A more rugged, adaptable, and durable autotransformer than its predecessors, the Type W20 Variac Autotransformer is the latest model to be announced in the new redesigned W Series.
General Radio Co. 1830

Sound-Level Meter—Smaller, lighter, and easier to hold than its predecessor, the new Type 1551-B Sound-Level Meter also has many worth-while new technical features and improvements.
General Radio Co. 1831

Scale—Scale portability for "on the job" weighing is featured in new additions to the Homs line of full capacity beam bench scales.
Douglas Homs Co. 1832

Whiteness Reflectometer—A new instrument has been designed to measure the whiteness, reflectance, yellowness, and opacity of white and near-white paints, papers, textiles, ceramics, foods, plastics, and soap products. It can be equipped with an ultraviolet absorbing filter which may be alternated between the incident and viewing light beams.
Hunter Associates Laboratory, Inc. 1833

Test Paperboard—A simple, accurate test instrument, called the Hunter Carbon Scorebend Tester to measure the force

Laboratory Items

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required to "break-open" flat folded paperboard cartons has been developed.
Hunter Spring Co. **1834**

Testing Chambers—The chambers are for use in the simulation of ultra low and high temperatures in ranges from −150 to +400 F, as well as high altitudes and precision humidity.
International Radiant Corp. **1835**

Small-Distance Measurement—Designed to measure distances in the 0 to 45,000 microinch range with very high accuracy, the new Electronic Micrometer, Type B-721, affords a unique method of measuring small distances without physical contact.
Wayne Kerr Corp. **1836**

Package Tester—A new and smaller Conbur (incline-impact) package tester with 400 lb capacity is now available. It has been developed for the smaller testing laboratories and for other facilities where additional equipment is needed to relieve overburdened test schedules.
L.A.B. Corporation **1837**

Environmental Cabinets—A new line of combination high and low temperature humidity environmental cabinets has been announced. Produced under the trade name "Weatherlab," the cabinets can sustain temperatures from −120 to 350 F and humidities from 20 to 98 per cent. Models range in size from 5 cu ft to large walk-in types.
Labline, Inc. **1838**

Carbon Determinator—Development of a new semi-automatic carbon determinator is announced. The new unit embodies a number of refinements. It eliminates the need of raising and lowering the leveling bottle and of stretching to seat the float valve.
Laboratory Equipment Corp. **1839**

Melting Point—A new melting point apparatus has proved to be successful in carrying out accurate, reproducible determinations in a minimum of time. Heating is rapid to within 5 or 10 C of the melting point. Further temperature increases can then be reduced to 1 or 2 C per minute.
Arthur S. LaPine & Co. **1840**

R-I-E Meter—A new R-I-E Meter said to be especially intended for laboratory and production testing where unusually stable measurements of resistance, current and voltage are desired has been announced. Applications include: resistance measurements from 2×10^2 to 2×10^8 megohms, with limits of error between ± 1.7 and ± 6 per cent of reading. Current measurements of 1×10^{-12} to 5×10^{-6} ampere, and voltage measurements of 0.005 to 500 v.
Leeds & Northrup Co. **1841**

Image Converter Camera—Model C Image Converter Camera is for photography of transient phenomena in the millimicrosecond region. The camera, designed around a newly developed image converter tube, is electrostatically focused and deflected.
Librascope, Inc. **1842**

Transmission Gratings—A new technique for ruling fine gratings which produces light transmission of high contrast has been developed. A series of lines are cut through a metallic film on glass in such a manner as to leave clear lines precisely separated by opaque strips equal in width to the lines ruled.
David W. Mann, Inc. **1843**

Recorder—An electronic strip chart recorder with continuous integration for rapidly fluctuating industrial processes has been developed. It measures, records and continuously totalizes any linear variable with respect to time. Although designed primarily for gas chromatography analysis it can be used to measure flow in continuous weighing systems.
Minneapolis-Honeywell Regulator Co. **1844**

X-Ray Units—Nondestructive testing can now be accomplished through the use of high output, precision-made industrial X-ray equipment manufactured by Rich. Seifert & Co., Hamburg, Germany.
Mitchell Radiation Products Corp. **1845**

Tension Controller—A new production model of the P/A Automatic Tension Controller has recently been announced. The major improvement in the new model involves the repackaging of the equipment with a more compact control panel in a heavy steel enclosure and a cast aluminum transmitter housing.
Pneumatic Applications Co. **1846**

Flash Point—This new Flash Point Recorder will take a sample automatically from a stream to which it is piped, run a flash test on it and record the result, all this repeating continuously at approximately 3-min intervals.
Precision Scientific Co. **1847**

Electronic Counters—A new line of totalizing and predetermined electronic counters for laboratory or production control service has been announced.
The Redford Corp. **1848**

Pulse Generator—Model 1051 Millimicrosecond Current Pulse Generator produces high amplitude, ultra short duration current pulses for development and design applications in high speed logic and memory problems, solid state research, and high speed transistor switching operation.
Rese Engineering, Inc. **1849**

Voltage-Calibrator—New Model 1080 Precision Voltage-Current Calibrator, the most recent addition to the complete line of specialized test equipment for the magnetics industry has been announced. Accuracy of the instrument is better than 0.3 per cent, and it is notable as a dual purpose instrument, operating either as a secondary standard of voltage, or as a comparator type calibrator.
Rese Engineering, Inc. **1850**

Hydraulic Test Loading—A new solution to the problem of loading airframe structures according to predetermined schedules is offered in the newly developed Hydraulic Test-Loading Equipment.
Research, Inc. **1851**

Centrifuge—Model S-15699 Centrifuge provides a maximum rotary speed at least twice that of micro and semi-micro centrifuges generally available, thus produces a sedimentation rate approximately four times that commonly offered.
E. H. Sargent & Co. **1852**

Wall-Mounted Tester—A wall-mounted tensile tester is now available. The hydraulic cylinder and jaw units, and the 8½-in. gage can be mounted on the wall. The only bench space required is for the 3 by 8 in. pump and integral reservoir base, and the manual pumping handle which extends forward 8½ in.
Steel City Testing Machines, Inc. **1853**

Vacuum Pumps—The new Stokes Compound Pumps are offered initially in two sizes: SC-2, of 2.3 cfm displacement, and SC-3, of 3.7 cfm displacement, suitable for many different laboratory and production applications where rapid pumping and an ultimate blankoff pressure of 0.1 micron are desired.
F. J. Stokes Corp. **1854**

Surface Plates—Tol-Check, a new instrument for checking the tolerance accuracy of any type or make of surface plate, is now available.
The Herman Stone Co. **1855**

Pressure Transducer—The Model S-30 is a dual-coil, variable reluctance transducer wherein both coils are active. Diaphragm displacement due to applied pressure will result in one coil increasing in inductance while the other decreases. It is designed for use with bridge type circuits where the transducer coils are used as two of the bridge arms.
Ultradyne, Inc. **1856**

Magnet—A new rotating 6-in. magnet, the V-4007-1, provides a lower-cost alternative to the rotating 12-in. magnet now in world-wide use. The V-4007-1 is mounted on ball bearings and turns 200 deg about the vertical axis.
Varian Associates **1857**

Power Regulator—A new, solid-state, regulated d-c power supply, the Model SR-1000 is especially designed for strain gage excitation. The unit provides a "floating" output, which makes it especially desirable for this purpose. Either side of the output may be grounded.
Video Instruments Co., Inc. **1858**

Outlet Box—Two new outlet boxes for use in service shops and laboratories has been announced. Model 20 is a multiple outlet box with six outlets, a neon indicator, and an "on-off" switch. Model 30 is a multiple selector box with four outlets independently controlled by four switches.
Waber Electronics **1859**

CATALOGS & LITERATURE

Stream Analyzers—The 8-page, 2-color catalog, *Bulletin CL-4000*, describes a complete line of process stream analyzers including industrial pH equipment, industrial gas chromatographs, infrared analyzers, oxygen analyzers, etc.
Beckman Instruments, Inc. **2511**

Voltmeter—*Bulletin 3018* describes the Model 81 Digital Voltmeter. The bulletin contains detailed information on the operation, circuitry, and specifications of the voltmeter, as well as a list of applications and accessories available.
Beckman Systems Div. **2512**

Spectrochemical Testing—A bulletin describing and illustrating spectrochemical laboratory testing and analysis facilities is now available.
Bowser-Morner Testing Labs., Inc. **2513**

Environment Chamber—A new 6-page

brochure showing walk-in environmental chambers for temperature, altitude, and humidity is available. The brochure describes complete missile test facilities and components testing units.
Conrad, Inc. **2514**

Shock Tester—An illustrated 16-page *Bulletin 4-70* describes full line of precision shock testers.
Consolidated Electrodynamics Corp. **2515**

Recorder—A low-cost digital logging system designed to provide a digitized output from potentiometer recorders or shaft inputs is described.
Daytex Corp. **2516**

Optics For Industry—Wherever visual inspection, comparison, checking or measurement is important in industry, this new 96-page catalog should prove a valuable guide to essential equipment. Listed are hundreds of quality control aids—measuring magnifiers, many types of microscopes, pocket comparators, illuminators, projection sets, etc.
Edmund Scientific Co. **2517**

Interferometers—An 8-page brochure, *No. 140-58*, describing a line of dilatation interferometers and quartz dilatometers is available on request. It outlines the theory of dilatation measurements and discusses the use of three instruments.
Gaertner Scientific Corp. **2518**

Vibration Meter—A new illustrated technical bulletin, *No. WK-B-731A*, has been issued, describing the new Type B-731A Vibration Meter, an instrument with wide electronic, industrial, and aircraft application and offering a new method of measuring distance and vibration.
Wayne Kerr Corp. **2519**

Digital Voltmeter—A bulletin describing the new KIN TEL Model 402 ac/dc Digital Voltmeter is now available.
KIN TEL Div. **2520**

Deflection Potentiometers—A new 6-page *Data Sheet E-51(a)* describing the Brooks Deflection Potentiometers is now available.
Leeds & Northrup Co. **2521**

Cyrogenics—"Kelvin Scale" is a news sheet of current information on cyrogenics and related subjects, which will be published periodically.
Arthur D. Little, Inc. **2522**

Laboratory Catalog—A 16-page catalog describes balances, viscosimeters, timers, and other laboratory equipment.
Lux Scientific Instrument Corp. **2523**

Microhardness Testers—A revolutionary new microhardness tester permits direct, accurate readings, corresponding to Vickers, within 15 sec, by measuring resistance hydrostatically. Eliminates a microscope, conversion charts and complicated tables. Illustrated and described in a new, two-color bulletin.
Newage Industries, Inc. **2524**

Yield Determination—The first in a new series of technical bulletins describing use of radioisotopes in routine chemical analysis is now available. *Technical Bulletin No. 1* outlines the use of radioisotopes in yield determination, a common analytical problem.
Nuclear-Chicago Corp. **2525**

Testing Machines—Important considerations about Universal Testing Machines of 1,000,000-lb capacity and over are analyzed and discussed in a new 12-page brochure.
Tinius Olsen Testing Machine Co. **2526**

Digital Clock—*Bulletin No. 8-41* illustrates and gives complete technical details on new universal digital clock with 3 independent outputs each resolved to 1 sec.
Panellit, Inc. **2527**

Automatic End Point Recorder—A 4-page, 2-color *Bulletin No. 703* describes this new instrument which quickly and automatically determines and records the end point (maximum temperature attained during distillation test) of a hydrocarbon mixture.
Precision Scientific Co. **2528**

Physical Testing—A 6-page illustrated brochure, *CRE Tensile Tester Bulletin*, describes the new Scott Constant-Rate-of-Extension Tensile Elongation Tester, with ultra-precise electric weighing, for stress-strain evaluation of all materials in the range 0 to 0.05 lb and 0–1000 lb or 0 to 25 g and 0 to 500 kg tensile load.
Scott Testers, Inc. **2529**

Moisture Meter—A new bulletin is now available on the Bouyoucos Soil Moisture Meter. This is of particular interest to agricultural and civil engineers, research groups, scientists and contractors.
Soiltest, Inc. **2530**

Pulse Transformers—A new technical bulletin describing a series of miniature encapsulated pulse transformers wound on

high permeability ferromagnetic cores has just been published.
Technitrol Engineering Co. 2531

Spectroscopic Electrode—The new S-58 Spectroscopic Graphite Products Catalog is the first in the spectroscopic field to be loose-leaf bound with provision to add information in all sections as new developments occur.
United Carbon Products Co. 2532

Solenoid Valve—A new 12-page catalog of high-pressure solenoid valves for hydraulic power systems describes two-way and three-way valves in both a-c and d-c models.
Waterman Engineering Co. 2533

Catalog—Latest issue of the Will Lablog *No. 3-59* offers recent developments of laboratory instruments and apparatus.
Will Corporation. 2534

Probes—A new short-form catalog covering the complete line of thermistor-based temperature measurement and control instruments is now available.
Yellow Springs Instrument Co., Inc. 2535

NEWS OF LABORATORIES

Fabric Research Labs., Inc., Dedham, Mass.—Research and development consultants in fibrous, organic, and related materials, has announced the publication of four pamphlets describing certain services performed by FRL.

General Hermetic Sealing Corp., Valley Stream, L. I., N. Y.—Custom, certified helium mass spectrometer leak test services are now available with the formation of the first mobile leak test laboratory by the General Hermetic Sealing Corp.

INSTRUMENT COMPANY NEWS

Leeds & Northrup Co., Philadelphia, Pa.—Changes in top management involving three new vice-presidencies were announced by I. Melville Stein, president. Also included were certain changes in high-level operating committees. A new post, vice-president—Technical Affairs, will be held by Nathan Cohn, formerly manager, Market Development Division, Marketing Dept. In another move, the present director of marketing, Donald E. Moat, becomes vice-president—Marketing, while retaining his former function. The present director of manufacturing, John F. Quereau, retains that function and becomes also vice president—Manufacturing.

St. John X-Ray Laboratory, Califon, N. J.—St. John X-Ray Laboratory now offers film badge service. All films together with the completed report will be returned within 24 hours.

George Scherr Co., Inc., New York, N. Y.—After an absence from the American market for a number of years the Carl Zeiss-Jena Optical Measuring Instruments have been made available again by the George Scherr Co.

OTS Research Reports

These reports, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Alumina-Base Cermets: Part 5. PB 151143, 75 cents.

Single Crystal Anisotropy and Magnetostriction Constants of Several Ferromagnetic Alloys. PB 151036, $1.25.

Investigation of Methods of Producing Single Crystals of Non-Metallic Ferromagnetic Substances, Final Report. PB 131631, $1.50.

The Study of Properties of Single Crystals for Use as Detectors and Crystal Counters PB 121537, $1.25

Development of Ferroelectric Ceramics. PB 121418, $1.50.

The Preparation of Single Crystals of the Oxides of the Transition Elements. PB 121176, 75 cents.

The Experimental Production of Thin Ferrite Films and a Survey of the Magnetic Properties of Thin Films. PB 121177, $1.25.

Magnetic Properties of Low Permeability Alloys. PB 121169, 50 cents.

Proceedings of Symposium on Barium Titanate Accelerometers. PB 151161, $4.00.

Preliminary Irradiations of the Ceramic Fuels UO_2, UO_2-Zr, and ThO_2-UO_2: Final Report. ANL-5675, $1.

le-Ductile Transition in Vanadium. C-1037, $2.50.
y Detection of Fatigue in Aluminum lloys by Ultrasonics. PB 151019, .25.
estigation of the Compressive, Bearing, and Shear Creep-Rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures: Part 3. PB 131977, $2.75.
Delayed Failure and Hydrogen Embrittlement in Titanium. PB 151139, $1.75.
Effect of Prior Creep on Mechanical Properties of Aircraft Structural Metals: Part 3—C110M Titanium Alloy. PB 151145, $2.25.
Metallography of Titanium Alloys. PB 121645, $2.75.
Department of Defense Titanium Sheet-Rolling Program: Uniform Testing Procedures for Sheet Materials. PB 121649, $1.25.
Correlation of Titanium Phase Diagrams. PB 131691, 75 cents.
The Compressive Creep Buckling of Metal Columns: Part 5—Cyclic Loading. PB 151218, $1.75.
The Role of Subgrains in High Temperature Creep. PB 151208, $1.
Acoustic Emission Under Applied Stress. PB 151215, $1.25.
Synthetic Mica High Temperature Strain Gage Research. PB 151045, $3.50.
Plastics and Adhesives: A Guide to Their Physical Properties and Uses. PB 131686, $2.50.
The Response of Linear High Polymers to Hydrostatic Pressure. PB 131684, $1.50.
Heat and Abrasion Resistant Paints for Rocket Launchers. PB 131543, 75 cents.
The Theory and Operation of a Dynamic Tester for Evaluating Package Cushioning Materials. PB 121692-S, 75 cents.
The Load Transmission Test for Flexible Paving and Base Courses: Part 6—Summary of Tests with Single-Tire Loading. PB 131890, 75 cents.
Measurement of Low Velocities in Liquids. DP-287, 75 cents.
The Effect of Fuel Ingestion on Turbojet Engine Operation: Part 1—J35 and J47 Engines. PB 131907, $1.25.
Airframe Lubricants: Part 2—Development of a Laboratory Technique for Determining Rust-Preventive Properties of Lubrication Greases. PB 151184, $1.50.
Heat Capacity Determination of Mineral and Synthetic Engine Oils, Lubricants, Fuels, and Hydraulic Fluids in the Temperature Range 70 to 500 F. PB 151210, $1.50.
Evaluation of Fungicidal Treatments for Cotton Fabrics. PB 151142, $2.50.
A Spectroscopic Test for Silicon in Silico-Organic Compounds. PB 151223, 50 cents.
A Catalog of Devices Useful in Automatic Data Reduction: Part 2, First Revision. PB 111928R, $5.
Mathematics for Digital Computers: Vol. 1—Multivariate Interpolation. PB 151200, $2.50.
Controlled Atmosphere Melting of Magnetic Materials. PB 121168, 50 cents.
Various Aspects of the Distribution of Fatigue Lives. PB 151211, $1.25.
Electrical Resistance Effects Associated with the Allotropic Transformation in High-Purity Iron. PB 151205, $2.
Relation of Wettability by Aqueous Solutions to the Surface Constitution of Low-Energy Solids. PB 151048, 50 cents.
Evaluation of High-Molecular-Weight Polyethylene Ropes. PB 131687, 50 cents.
Infrared Absorption Spectra of Bromohydrocarbons in the 15 to 35 Micron Region. PB 151134, $1.

Cellulose to be Subject of New York Symposium

A symposium on chemical methods for testing cellulose will be held at the Commodore Hotel in New York, February 25. Seven papers will be presented during the two sessions of the symposium, which will be held in conjunction with the annual meeting of the Technical Association of the Pulp and Paper Industry. The program is sponsored by TAPPI, ASTM, and the American Chemical Society.

Federal Government Standards Changes

The Federal Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplement No. 8 for the month of October 1958.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Code	FSSC Class	Assigned Agency and Preparing Activity
Adhesive Compound Fatty Acid Pitch (For Use With Fiber Glass Roofing, Roll Roofing, Roofing Fabric)	New	SS-A-150a	5650	..	HHF-PHS
Boxes, Wood, Nailed and Lock-Corner	Am. 2	PPP-B-621	8115	..	Navy-S&A
Cable and Wire, Weather-Resistant	Am. 3	J-C-145	6145	18	GSA-FSS
Chemicals, Liquid, Packaging and Packing of..	New	PPP-C-300	..	..	DOD-Army-CmlC
Pipe, Steel (Seamless and Welded, Black and Zinc-Coated (Galvanized))	Rev.	WW-P-404a	..	..	DOD-Army-QMC
Plastic Film, Polyester ..	New	L-P-377	9330	57	GSA-FSS
Steel Strapping, Round (Bare and Zinc-Coated)	Am. 1	QQ-S-790b	8135	..	DOD-Army-QMC

(*Continued on page 95*)

(Continued from page 94)

WITHDRAWALS

Title	Type of Action	Symbol or Number	Assigned Agency or Technical Committee	Reason for Withdrawal
Wire, Asbestos-Insulated (Type AIA) ..	New	..	COM-NBS	Project not needed at present time

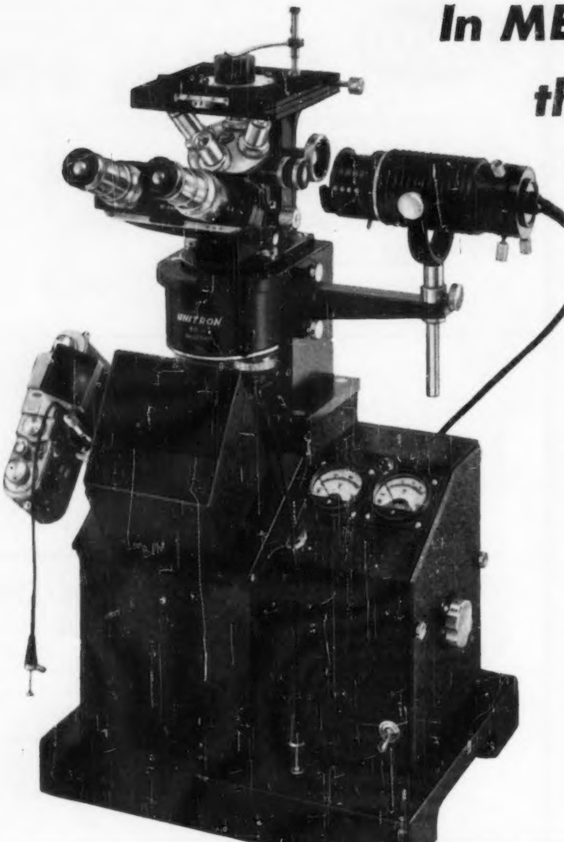
PROMULGATIONS

Title	Type of Action	Symbol or Number
Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling, and Testing	New	Fed. Test Met. Std. No. 141
Aluminum Alloy Bar, Rod and Wire (Free-Machining) (Superseding QQ-A-365a)	Rev.	QQ-A-365b
Aluminum Alloy Die Castings (Superseding QQ-A-591a)	Rev.	QQ-A-591b
Box, Paper-Overlaid Veneer (Strap-Around Type)	Am. 1	PPP-B-575
Boxes, Paperboard, Metal Stayed (Including Stay Material)	New	PPP-B-665
Calcium Chloride, Dihydrate and Calcium Chloride, Anhydrous, Technical (Superseding O-C-00105(GSA-FSS))	New	O-C-105a
Gasoline, Automotive (Superseding VV-M-561a) ..	New	VV-G-76
Plastic Compounds, Molding and Extrusion, Polyethylene	Am. 1	L-P-590
Plastic Sheet, Polystyrene, Modified	New	L-P-515
Solder, Lead Alloy, Tin Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form ..	Am. 1	QQ-S-571c
Tape, Pressure-Sensitive Adhesive, Identification (Acetate-Fiber) (Superseding L-T-0099(GSA-FSS) and L-T-101 (in Part))	New	L-T-99a
Tube, Steel, Carbon, Mechanical, Round; Seamless and Welded (Superseding QQ-S-00643 (Army-Ord))	New	QQ-T-830
Wood Preservative: Osmosar (Osmosalts)	Am. 1	TT-W-569

INDEX TO ADVERTISERS

In METALLOGRAPHS . . .

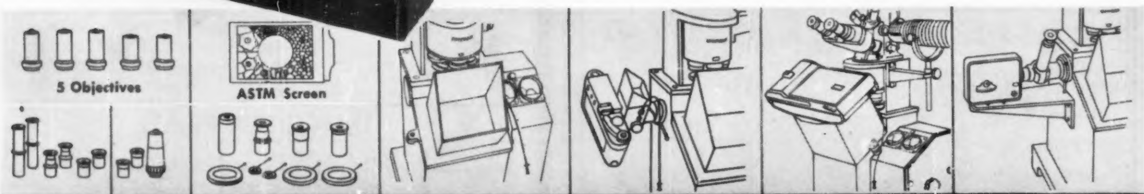
the trend is to UNITRON!



What do you look for when choosing a metallograph? All of the popular makes are precision instruments, are reasonably versatile and, to a varying degree, are easy to operate. But, except for UNITRON, all have the bulk of an office desk or optical bench and are tagged with a price that puts a substantial dent in the laboratory budget. UNITRON, and only UNITRON, offers a completely equipped metallograph in a compact and self-contained unit, taking only 9″ x 12″ of table space, which duplicates the performance of large cumbersome instruments — and at a price which is hardly more than the usual cost of a conventional metallurgical microscope.

Unlike the case with most metallographs, an adding machine is not required to compute its cost. Coated optics supplied as standard equipment include 5 objectives, 4 photographic eyepieces and 3 pairs of visual eyepieces. These give a magnification range of 25X-2000X. Also included in the purchase price are the built-in 3¼″ x 4¼″ camera and viewing screen; high-intensity illuminator for vertical, oblique, and transmitted light; variable transformer with both voltmeter and ammeter; accessories for transparent specimens; polarizing apparatus; filters; film holders; stage clips; cabinets etc. Optional extra accessories include Polaroid Land, 35mm. and movie camera attachments; low power (5X-40X) objectives for macro work; vacuum heating stage for temperatures to 1100°C and long working-distance 40X objective; ASTM Austenite grain size viewing screen and eyepieces; filar micrometer eyepiece; and additional optics.

Such a combination of features, versatility, convenience, and value is indeed unique with UNITRON. Little wonder then, that more and more laboratories are choosing UNITRON . . . from the large organization adding another metallograph to its equipment, to the small company buying an instrument for the first time.



Visual Eyepieces	Accessory Eyepieces, Objective	4 Photographic Eyepieces, Filters	Standard 3¼″ x 4¼″ Camera	Accessory 35mm Camera	Accessory 3¼″ x 4¼″ Polaroid Land Camera	Accessory Motion Picture Camera

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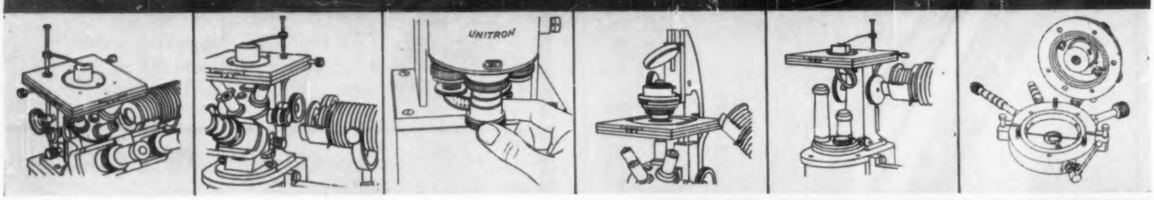

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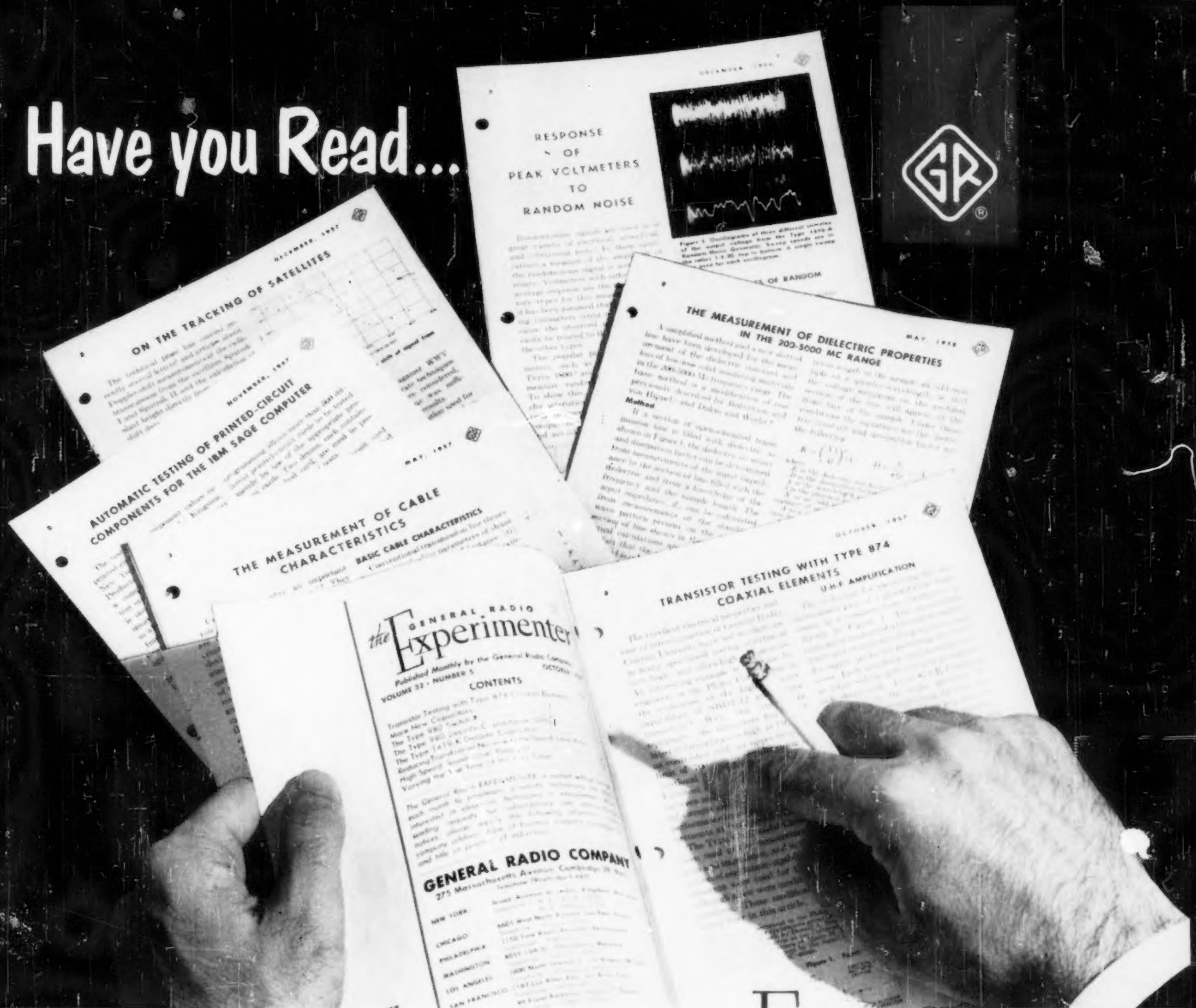

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